

THE PSYCHOLOGICAL REVIEW

THE PROBLEM OF INHIBITION

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With the discovery of the effect of the vagus on heart,¹ the inhibitory influence of higher centers on reflex activity, and the interference of various stimuli with the reflexes of the frog,² inhibition became one of the notable problems of the operation of the nervous system. The researches of Sherrington gave us an entirely new idea of the importance of inhibition in gross behavior. His experiments demonstrated that it functions in the economy of organic behavior not merely as a conservative factor but also in the fine grading of the strength of reactions and in rhythmic alternating movements; such as stepping, flying, swimming, and the movements of respiration.³ It also plays a major rôle in the conditioned reflexes of Pawlow and in what we ordinarily call training. But notwithstanding its scientific significance and an almost overwhelming literature its physiological nature still remains obscure.⁴

¹ Volkmann, Müller's *Arch. f. Anat. u. Physiol.*, 1838, 87 ff. Weber, E. H., Müller's *Arch. f. Anat. u. Physiol.*, 1846, 483 ff. Weber, Ed. *Muskelbewegung*, Wagner's *Handwörterbuch d. Physiol.*, 1846, 3, 37 ff.

² Volkmann, Wagner's *Handwörterbuch d. Physiol.*, 1844, 2, 534 ff. Setschenow, 'Physiologische Studien über die Hemmungsmechanismen,' Berlin, 1863. *Ann. des sci. nat.*, 1863, Series IV, 19, 109. Herzen and Schiff, 'Expériences sur les centres modérateurs de l'action réflexe, Turin,' 1864. Goltz, 'Beiträge zur Lehre von den Functionen der Nervencentren des Frosches,' Berlin, 1869. Wundt, 'Untersuchungen zur Mechanik der Nerven,' 2te Abt., Stuttgart, 1876. Langendorf, *Arch. f. Physiol.*, 1877, 96, 435.

³ Sherrington, *Sci. Prog.*, 1910-11, 5, 584. Meltzer, *Med. Rec.*, 1902, 61, 881.

⁴ Sherrington, *Quar. J. Exper. Physiol.*, 1913, 6, 254. Forbes, *Physiol. Rev.*, 1922, 2, 280. Adrian, *Brain*, 1924, 47, 399.

Many instances which more or less closely resemble the phenomena of inhibition as described by the physiologists have been noted in mental life. The earliest observation that a more intense pain overcame a lesser one is credited to Hippocrates. Probably the most extensive use of the concept of inhibition is Herbart's attempt to found a mechanics of ideas. Consistent attempts to exploit inhibition as a fundamental neuro-psychological process were made by Exner¹ and Verworn.² It has been more or less conspicuous in every systematic psycho-physiological description of human consciousness and behavior. The most frequent outcrops of the concept of inhibition in experimental psychology have been in connection with investigations of attention, memory, choice and the conflict of impulses, the rivalry of sensory stimuli, and the effects of practice. In Wundtian psychology it became the physiological substratum of the fundamental process of apperception. In the Freudian school it plays a dominant part.

It is a scientific tragedy that in all this exploitation of the concept of inhibition, notwithstanding many unproven hypotheses of far-reaching psychophysical import there has been no satisfactory analysis of the processes and no conclusive proof that what the physiologist means by neural inhibition has any real relation to mental phenomena. In view of the physiological uncertainty with respect to the nature of inhibition it is not altogether the fault of psychology that the physiological concept has come to be used somewhat uncritically. But without further argument I venture the thesis that if we continue to use the concept of inhibition, psychologists have a real stake in the task to help investigate with such resources as may be available not only the apparent outcrops but also the nature of the process. It is of doubtful scientific value to construct hypothetical schemes of neural action to account for the observed facts of mental life unless the hypotheses can somehow be submitted to experimental

¹ 'Entwurf zu einer physiologischen Erklärung der psychischen Erscheinungen,' Leipzig, 1894.

² 'Die Mechanik des Geisteslebens,' Leipzig, 1910.

test. Facts without hypotheses are dead, but hypotheses which cannot be verified might as well be.

RESPONSIBILITY OF PSYCHOLOGY

Restricted in the method of direct experimentation to techniques that may be applied to intact and complex nervous systems, the experimental psychologist is peculiarly dependent on the results of physiological experiments with isolated tissues and simple systems both for his working hypotheses and his elementary facts. But he must take scientific responsibility for testing the extension of these hypotheses and facts to the complex conditions of human behavior, experience, and personality. Both his limitations and his responsibility impose special obligations to scientific caution. While it is often regarded as unfortunate that nerve fibers, nerve muscle preparations, and reflexes cannot be functionally isolated in the intact human on demand, it may not be forgotten that it is exactly in the mutual interrelationships of the various neural strata in human behavior and the integration which is called consciousness that there lies a group of problems of the utmost practical importance.

Fortunately along side of the highly complex processes peculiar to the cerebrum simpler systems are accessible even in humans which are comparable with the reflex preparation of the physiologists. While these simpler structures may never be completely separated from the action of superior systems in normal human life, their low latency, specific excitability, and early development often give them a position in neural organization which permits differential experimental study. Complete separation from the rest of the nervous system would rob them of their peculiar human significance. They should serve as a connecting link between the nerve muscle preparation and the more elaborate processes with which the psychologist is chiefly concerned.

Our ignorance of the nature of inhibition is not unique. Even the most fundamental questions in the physiology of the nervous system, how stimuli produce neural action, how excitation is propagated within the axone and from neurone

to neurone, and how neural action produces muscle contraction, are not without their scientific difficulties. While these questions still remain incompletely answered, familiarity with the phenomena, and apparent but often only illusory correspondence with the common interpretation of the law of the conservation of energy, give the positive effects of stimulation a relatively simple appearance. The increase of neural action by increased stimulation seems almost axiomatic. Decreased neural action by increased stimulation on the contrary seems strange and unreasonable, opposed to common experience and to the fundamental laws of dynamics. Doubtless, in part at least, on account of these pseudological barriers, the decrements which are effected by stimulation have received relatively less attention in psychology than the positive effects of stimulation. Even in physiology there have not been wanting impatient voices that would have done with inhibition.

Notwithstanding all this, there is a widespread conviction that in both simple and complex systems the inhibitory effects of stimulation are just as real and fully as important as the excitatory effects. In a paper on 'Habituation to Rotation,'¹ I pointed out evidence of certain analogies between the process of learning and the inhibition of after-nystagmus in a series of rotation experiments. At that time I expressed the hope for some direct experimental evidence as to the nature of inhibition in human neural processes. This and succeeding papers are steps towards the realization of that hope.

VARIETIES OF INHIBITION

One may well bear in mind the physiological as well as psychological warnings² that possibly there are several different kinds of inhibitory processes. Certainly the arrest, decrement or discontinuance of human action consequent to changes in the external vital conditions are of various appearances. One of the simplest behavioristic aspects of arrest is the mechanical inhibition exercised by antagonistic muscles. The knee-jerk for instance may be voluntarily reinforced by additional arbitrary contraction of the leg extensors.³ This

¹ Dodge, R., *J. EXPER. PSYCHOL.*, 1923, 6, 1.

² Sherrington, Roy., *Soc. Proc.*, 1905, 76 B, 269.

³ Dodge, R., *Zsch. f. allg. Physiol.*, 1910, 12, 23.

reaction may become by a little practice the habitual response to the same blows on the patellar tendon that produce the reflex. It is in nature a purely mechanical reinforcement due to a secondary contraction of the quadriceps muscles consequent to a delayed conduction from the proprioceptors probably through the cortex of the cerebrum. In an analogous manner the extension of the leg may be stopped before it has reached its maximum amplitude in the knee-jerk by an arbitrary contraction of the flexors. With adequate recording technique (where the record is made by the thickening of the quadriceps on the one hand and of the antagonistics on the other) this decrease in the amplitude of leg movement may be shown to be due to the mechanical interference of antagonistic muscles. Holt¹ reported a similar inhibition of vestibular nystagmus by lateral fixation. It is possible to produce in this way a purely mechanical decrement in the amplitude of extension of the leg quite apart from all question of central inhibition and neural conduction with decrement.

This peripheral terminal inhibition of the movement of a limb by the action of antagonistic muscles is common enough in human life. Initial contraction of antagonistic muscles was found by Langfeld² as the effect of negative instructions. When we stretch muscle pulls against muscle without gross movement of the limbs; we shut our jaw to keep back speech. We open the eyes wide to prevent winking and grip the dentist's chair in part at least to keep our hands from interfering with his particular modes of stimulation. There may be some question whether this inhibition of action in typical forms of behavior falls within the proper definition of inhibition, even though the usual definitions do not specifically exclude it. Certainly terminal inhibition is different from either central or reflex inhibition. Its conditions and course are relatively simple. Its nature is entirely clear. This may be regarded as an extreme case, but in the group of phenomena that are more specifically neural inhibitions there may be anomalies that are just as real if not as obvious.

¹ Holt, E. B., *Harvard Psychol. Studies*, 1906, 3, 72.

² Langfeld, H. S., *Psychol. Rev.*, 1913, 20, 459-478 esp. 476.

Hesitation and block not infrequently appear in normal human behavior consequent to the interplay of opposed motives or mutually contradictory data. While this central conflict bears a superficial resemblance to the simultaneous enervation of antagonistic muscles and is not infrequently hypothetically identified with it, there is no direct evidence in physiology or psychology of any real antagonistic neural action aside from rivalry and competition for a final common path.

Two other varieties of inhibition of the knee-jerk are sharply differentiated in my experience from terminal mechanical inhibition. When a second blow on the patellar tendon follows its antecedent within an interval of less than half a second, if the stimulus blows remain the same, the second thickening of the quadriceps muscle is regularly less extensive than the first. In this case the second stimulus is said to fall within the 'relative refractory phase' of the first reaction.

The refractory phase was first demonstrated in the heart muscle by Kronecker and Sterling¹ and by Marey.² The discovery of a similar phase in the central nervous system was made by Broca and Richet.³ The phenomenon of the refractory phase was found in a variety of neuromuscular systems by Verworn and his school,⁴ in deglutition by Zwaardemaker,⁵ in nerve by Gotch and Burch,⁶ and Lucas,⁷ in various reflexes by Sherrington,⁸ in the knee-jerk by Dodge,⁹ and in the lid reflex by Zwaardemaker and Lans and Dodge.¹⁰

¹ *Festschrift z. Ludwig*, Leipzig, 1874.

² 'Travaux du Laboratoire,' 1876, 73 ff. *C. r. Acad. sci.*, 1891, 82, 408 ff.

³ *C. r. Acad. sci.*, 1897, 124, 96 ff.

⁴ *Allg. Physiol.*, 1909, 558 ff. 'Irritability,' New Haven, 1913, 154 ff. 'Erregung w. Lähmung,' Jena, 1914, 145 ff.

⁵ Zwaardemaker, *Arch. int. de Physiol.*, 1900, 1, 1-16.

⁶ Gotch and Burch, *J. Physiol.*, 1899, 24, 410 ff.

⁷ Lucas, *J. Physiol.*, 1909-10, 39, 331 ff. 'The Conduction of the Nervous Impulse,' London, 1917, 28 ff.

⁸ Sherrington, *J. Physiol.*, 1910, 40, 30. *J. Physiol.*, 1906, 34, 1. 'The Integrative Action of the Nervous System,' N. Y., 1906, esp. 44 ff.

⁹ Dodge, *Zsch. f. allg. Physiol.*, 1910, 12, 53 ff.

¹⁰ Zwaardemaker and Lans, *Centralblatt f. Physiol.*, 1899, 13, 325 ff. Dodge, *Am. J. Psychol.*, 1913, 24, 1 ff.

It may be presumed to be an essential part of the post-stimulation phenomena in all irritable tissue, including glands, muscles, axones, and central nervous systems. How far it operates in the complex conditions of human experience and behavior no one has investigated. There are many events that appear to fit the general framework of refractory phase. Evidence is not wanting on the one hand that stimulation of any given intensity may be too frequent for usual reaction and that new stimuli introduced during a decrement of excitability subsequent to initial stimulation may fail to induce normal reaction. On the other hand it is certainly untrue that all inhibition of neural arcs depends on and follows only their normal reactions. Before the concept of the refractory phase can be applied to any of the usual varieties of decrement by additional stimuli, one must ask the plain experimental question, 'What are the neural effects of subthreshold stimuli?' That they occasion some change in the neural systems on which they impinge is seen in the phenomena of summation of subthreshold stimuli as well as in the perpetuation of the refractory phase by stimuli that are too weak to produce a regular reaction. The whole field of subthreshold stimulation has scarcely been touched by experimentation either in physiology or in psychology though its problems and speculative solutions date back at least to Leibnitz.

In addition to the decrement of refractory phase, it was also possible to decrease the muscular response to a blow on the patellar tendon by a voluntary and entirely arbitrary deadening of excitability, the exact nature of which I have as yet been unable to determine. This deadening was initiated by a complete relaxation of the thigh muscles, but it seems to consist of something more than that which could not be recorded mechanically from the muscle. It appears in introspection to resemble a detachment, deadening, or going to sleep of the limb. Similar phenomena in the mental life appear in sleep and drowsiness. Pawlow¹ in a recent summary of his work regards inner inhibition and sleep as fundamentally the same.

¹ *Skand. Archiv f. Physiol.*, 1923, 44, p. 35.

"Recently, after prolonged collection of facts and after testing many hypotheses, we have come to the conclusion that inner inhibition and sleep are fundamentally one and the same process. In inhibition this process is closely localized, one might say particularized, while in ordinary sleep it is continuous. I regret that lack of time prevents a more complete discussion of this important point, and shall only mention one fact of great importance. If a more or less protracted stimulus, no matter what its significance may be in the life of the animal falls on a single point of the cortex and is neither superseded by the stimulation of other points nor accompanied by the simultaneous stimulation of other points, it tends inevitably sooner or later to the inhibition of this point and afterwards to general sleep."

THE PHENOMENA OF DEADENING A REFLEX

The first appearance in voluntarily deadening a reflex is real decrease in muscle tonus. This is evidenced by records from the muscle and more simply by observing a decreasing resistance to gravity. If it is free to move, the limb glides to a more stable equilibrium. It falls or swings against supports or hangs limp from its center of rotation.

Subsequent to this initial relaxation further depression of tonus appears to be exceedingly slow or entirely wanting while the deadening process reaches wider areas and possibly increased depth. The relaxed limb comes to have a numbness and a feeling of detachment as though it never could move again and didn't belong to the body. The spread of the deadening is irregular, following voluntary attention to the several parts of a limb or to various limbs. Each in succession may be felt to press more firmly against its support or to hang more limply from its hinges. In extreme cases the eyes close. In some way the depth of the process also seems to be related to depression of inspiration. There is for a time an almost complete disinclination to breathe. It seems for a few seconds as though one never would breathe again. This ends in a disturbing spasm of inspiration. I conjecture that with some non-exciting artificial respiration, or the artificial elimination of the CO_2 stimulus to respiration, the depth of relaxation might eventuate in normal sleep.

Something similar appears to occur in the intermittance of pain which is conditioned by excessive pressure. In contrast to the inhibition effected by attention there is no apparent rivalry and displacement by other conscious contents, but

rather an intermittent breaking through of the pain sensations. How far these spasmodic exacerbations are controllable and capable of delay would make an interesting experiment with many practical leads and the possibility of a better understanding of some abnormal phenomena.

The phenomenon is not simple adaptation. It is directly conditioned by intent. Similar phenomena without intent are found in the depressing effects of some drugs, such as ether, chloroform, alcohol, and morphine; and by the partial products of decomposition, such as, CO_2 and the fatigue toxins. To these could probably be added some of the depressant glandular secretions and the chemical conditions or products of auto-intoxication. All these are true stimuli in the sense that they are changes in the external vital conditions of tissue.

OTHER VARIETIES OF INHIBITION

Objectively, quite different still is the total inhibition of a reflex that occurs as the consequence of rivalry and competition for a final common path. This variety of inhibition has been frequently described by Sherrington.¹ Only one case (so far as I know) is graphically recorded in the complex conditions of the intact human nervous system.² When visual stimuli compete with opposed vestibular stimuli each tends to produce slow movements of the eyes in opposite directions (respectively, the slow phases of pursuit and compensatory eye movements). Under certain circumstances the visual stimuli come into exclusive control of the final common path to the eyes and completely inhibit the opposed vestibular reflex. This inhibition may appear after a more or less protracted period of rivalry and apparent confusion. It regularly has a relatively long latency of the order of a quarter of a second. But when the dominance of the visual pursuit is once established, and as long as adequate visual stimuli persist, the vestibular reflex may be as completely inhibited as though it had not existed. If the visual stimuli are suddenly withdrawn while the vestibular stimuli persist, the reflex

¹ Sherrington, *Brit. Assoc. Reports*, 1904, 734.

² Dodge, *J. Exper. Psychol.*, 1923, 6, 177 ff.

emerges suddenly and completely. The latent time of the reflex emergence is very short, too short to be measured in our photographs. The subsequent course of the vestibular nystagmus is as though it had never been interrupted. That is to say, the amplitude and frequency of the reinstated vestibular nystagmus correspond to that stage of adaptation that would have been reached if the reflex had not been temporarily interrupted. This variety of inhibition has many analogies in mental life in attention and memory. As we shall point out in a subsequent paper our records show that it is incompatible with the Drainage Theory.

One of the most regular varieties of inhibition is represented by Heymans' ¹ Law. In a number of sensory fields Heymans measured the inhibitory power of a stimulus by the intensity of the stimuli that it is capable of rendering sub-threshold. In a series of strikingly consistent experiments on a single subject, he found the general law that the inhibitory power of a stimulus increased in direct proportion to its intensity. Heymans' Law has been confirmed and generalized by various experimenters, notably by Spencer's ² experiments on the white rat and a group of human subjects. He found further evidence of its central origin in the inhibitory effects of a stimulus which was given to one retina on threshold stimulation of the other retina.

An unique form of inhibition which was discovered early in the history of response of nerve to electrical stimulation by the constant current is the anode block.³ While this has no known analogies in normal physiology or psychology, there are several phenomena of systematic or persistent inhibition that superficially resemble this form of inhibition such as prejudice, set, and some of the associative inhibitions.⁴ There seems to be no inherent impossibility in the hypothesis that

¹ *Zsch. f. Psychol. u. Physiol. d. Sinnesorgane.*, 1899, 21, 321-359; 1901, 26, 305-382; 1904, 34, 15-28; 1906, 41, 28-37, 89-116; 1909, 53, 401-415.

² *J. Comp. Psychol.*, 1923, 3, 389-408. *Amer. J. Psychol.*, 1925, 36, 427-433.

³ Wundt, 'Mechanik der Nerven,' Erlangen, 1871, 25 ff.

⁴ Kline, *J. EXPER. PSYCHOL.*, 1921, 4, 270 ff. Shepard and Fogelsonger, *PSYCHOL. REV.*, 1913, 20, 291 ff. Langfeld, H. S., *PSYCHOL. BULL.*, 1910, 7, 200 ff. *PSYCHOL. REV.*, 1911, 18, 411 ff.

persistent stimuli in complex neural systems as in simple ones may artificially produce a region of decrement somewhere in the system that they affect which operates to extinguish subsequent excitations.

The most notable instances of systematic inhibition were those which were found by Sherrington in the reciprocal innervation of antagonistic skeletal muscles. The convincing experimental evidence for this form of inhibition led to its complete adoption in psychological tradition and to its more or less uncritical extension to many mental phenomena where real opposition has been difficult or impossible to prove.

In contrast to these relatively ephemeral forms of inhibition is that form of central inhibition by which excitability is gradually diminished through a series of stimulations. For example, in successive instances of rotation it has been found by various experimenters and confirmed by photographic records of the eye movements that there is a gradual change in the character of the reflex nystagmus of rotation. With closed eyes the nystagmus of acceleration as well as of deceleration gradually decreases in amplitude and frequency to bare beginning reflexes. The slow phase of the nystagmus which is the true reflex compensatory phase gradually decreases in angular velocity and becomes progressively less and less adequate as a mechanism for maintaining a fixed position of the line of regard. The more or less adequate initial angular velocity of the eye reactions to the beginning of the first instance of rotation is gradually inhibited in subsequent instances by some neural mechanism of which we are profoundly ignorant. I have elsewhere pointed out some significant practical implications of these experimental results.¹ Similar decreased reflex responses were found in a protracted series of measurements extending over a year and a half in both the lid reflex and the knee-jerk. It corresponds to the effects of practice and training.

Whether there are in addition other types which correspond to mental processes such as attention and will is an open question. There may be in fact many mechanisms of inhi-

¹ J. EXPER. PSYCHOL., 1923, 6, 33.

bition, of which we now know nothing whatever. It is conceivable on the contrary that all the various forms may be reduced by more adequate analysis to a few fundamental types, or even a single fundamental process.

The moral is obvious. There are in the literature many theories of inhibition. Evidence that one is true does not disprove the others. Each must stand or fall by the specific evidence that may be found to prove or disprove it. Perhaps in the end we shall not be content to refer to the rôle of inhibition in our mental life but shall enquire rather as to the rôle of a variety of fundamental conditions of decrement.

SUMMARY

Notwithstanding a long scientific history inhibition still remains an outstanding problem of neural physiology.

If psychologists continue to use the term, they should take responsibility for evidence of its occurrence and for investigation of its nature in human neural systems.

Several varieties of reaction decrement from additional stimuli appear in human behavior: peripheral terminal inhibition, refractory phase decrement, voluntarily decreased tonus, rivalry and competition, inhibition of weaker by stronger stimuli (Heymans' Law), anode block, reciprocal inhibition of antagonistic muscles (Sherrington), protracted inhibition consequent to frequent stimulation.

Disproof of one theory of inhibition does not necessarily disprove others. It may be necessary to analyze the inhibition concept into various fundamental conditions of decrement.

IS THE CEREBRUM THE SEAT OF THINKING?¹

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What is a man doing when he is thinking? Surely he is doing *something*. The photographic picture of a thinking person may be one of great immobility: he may be sitting still with chin on hand and elbow on knee. But the pose is not by any human observer mistaken for an inert state such as sleep. Any intelligent five-year-old child knows that something is going on inside this man. The child would say, 'He is thinking.' Now when thinking is going on, *what* is going on? Does the child, or does the adult, have anything more in mind when that word is used?

One meaning of the term has secured itself well enough in popular speech. When a person thinks, so this usage has it, he is having conscious experiences that are in some degree independent of the physical environing world; a series of represented things appear to him in sequences varying all the way from the panoramic type to the kaleidoscopic.

The attention of psychologists has long been much directed to these successions or streams of experiences; and the more time-honored workers have been interested largely in problems they can find therein. They have attempted to identify the different kinds of streams; they have studied the degrees in which each stream of thought was orderly and self-consistent or fantastic and capricious. They have beaten the bushes to unmask any hidden will-element or demon controlling the general flow of this succession; they have asked whether it is identifiable in the stream and of it. The better to analyze this flow of experiences, they have laid violent hands thereon and chopped it up into transitive currents and substantive stops; they have abstracted the stops and congealed them into

¹ Address of the president, The Southern Society for Philosophy and Psychology, Chapel Hill, April 13, 1925.

'ideas,' calling them simple or complex. They have studied the interrelations of these atoms of experience and therefrom deduced laws of their association and conglomeration. Thus and much further has gone the study of thinking as an exercise in the description of how much a person is aware, and of what he is aware when he is thinking. This point of view has been unintentionally caricatured by the cartoonist, Briggs, when he pictures a baby in a rather complicated situation and asks, "What is baby thinking about?"; proceeding then to the unveiling of most impossible 'thoughts.' It is also the point of view of the hunter who, in his philosophical moments, may wonder what his dog, standing at rigid attention upon sighting the quail, is thinking about.

Now, whatever independence psychologists have claimed for this study of man's nature by merely describing what that man experiences, it remains true that the program has never attained absolute self-sufficiency as a scientific one. Scientific interest is primarily an interest in the ascertaining of inevitable sequences, the so-called causal relations, and the very survival among many philosophers of the epistemological alternatives of parallelism and interactionism is due in part to the recognition on all hands that merely a mode of experiencing something, the merely being aware of it, cannot be conceived as a force or factor or cause that would budge a feather one millimeter. As soon expect the pattern of a dictophone record, of a phonograph, of a kymograph tracing, *itself* to effect changes in the material on which it is recorded that depend specifically upon the exact design of the pattern. No, if we be interested in scientific explanation, we must seek our ultimate causal sequences not in a man's conscious experiences *per se* but in his objective physical mechanisms; and so it is that, whether they belong to the introspectionist, behaviorist, purposivist, structuralist, functionalist, or other sect, psychologists acknowledge that the final basis for explaining why one sees blue at one time and feels blue at another is a matter of physiology. Your having of any experiences whatever is conditioned upon the functioning of your bodily organism. 'Why the mind has a body,' then, is as intelligible, and no more so, as the query, 'why life has matter.'

To return to our question, "When a man is thinking, what is he doing?" The answer, it is now clear, must be sought in physiological terms. The orthodox manner of treating of the physiological processes of thought is, after making the subjective description, to offer a scheme of brain paths. Thinking, we seem to agree, intervenes or occurs somehow between the arousing stimulations from our surroundings and the later reciprocating reaction, between some original sense organ receptivity and some ultimate motor organ response. Then, our question here takes the form: Just where and how, between the moment of original stimulation and the moment of ultimate reaction, does the thinking come in?

The view we must first examine is that the thinking is all done within the cerebrum, is based upon rapid shiftings, shuntings, and shootings of nerve impulses hither and thither from point to point on the cortex. What ground is there for this view? Well, there has been fair success in finding localizable areas on the cerebral cortex whither the original energy changes in the sense organs are conducted, and in finding other areas whence energy changes are despatched to motor organs to arouse the ultimate response. What else is more natural to infer, then, than that the energy changes forming the bodily aspect of the thinking going on in the meantime consist of local happenings in the immediate neighborhood; consist, that is, of a rapid fire shooting back and forth, hither and yon, of nerve impulses from one cortical area to another, thence to another, thence to another, and so on, until these captive impulses, perchance, arrive at certain areas where they are at last transferred to outbound peripheral pathways leading to termini in muscles and glands in the 'outer' body?

This shuttle-cock conception of what goes on in thinking at least has simplicity in its favor. Following the analysis of one's thinking experience into substantive perchings and transitive flights, it is convenient to think of the various perchings, the ideas, as residing in or based upon the various cerebral areas, and to think of the quick flights between idea and idea as riding upon or depending upon the impulse shootings. This manner of conceiving the business leads

some to such a description of the brain as the ascription of particular ideas to particular cells or small cell groups, and of more and more general ideas to larger and larger constellations of these cells, or to agents of such constellations located as cell groups elsewhere on the cortex. But what is the actual status of cerebral localization today? At the most, we have some definite knowledge of the projections of specific sensory and specific motor peripheral organs upon certain areas of the cortex, and the correlation of certain disorders in the general functioning of such peripheral organs with certain vaguely bounded areas; but we have scant evidence indeed for localizations of any functions other than those connected with specific bodily organs. At the least, we have frequent reminders by brain physiologists (as Franz) that the cerebrum acts as a whole, and that so much vicarious functioning really occurs, that brain mapping by psychologists is commonly carried too far.

An important point to be noticed is that any objective scientific attempt to untangle the physiological principles operating among these intracerebral shuntings of nerve impulses is, in the nature of the case, decidedly limited. As I have already said, objective methods (such as pathology, anatomy, experimental stimulation, etc.) isolate some special centers of projection upon the cortex of somatic or peripheral sensory and motor organs. They can identify in a rough way the general areas involved in certain complex functions that depend upon specific peripheral organs, as the uses of language. But in the very nature of the case we are debarred from breaking entrance into the cerebrum itself to observe just how different impulses in transit mutually influence or succeed each other. No, the laws and principles of the interplay of such transmissions are hidden from the eye and from the laboratory instrumentation of mere man.

To be sure, we do see some schemata, some cerebral neurograms, here and there, in psychological literature. But these, it is obvious, are not based upon direct knowledge of brain functioning in thought; they are little more than an attempt to visualize in a simple way, under the general form of neu-

rones, the principles already analyzed out of one's experiences of himself thinking. They are hypothetical to the n th degree. He who wishes objectively to get at the mechanics of thinking, to determine the phenomena and the principles involved, may provide the occasion and the stimulus for starting his man a-thinking, but he must perforce then sit down and wait patiently until the final result appears, until the man's thought issues in overt action or speech. The intra-cerebral exchanges of nerve-impulses are forces beyond his ken and his reach.

The bankruptcy of this attempt need not dismay us. Because we cannot study thinking objectively on this conception of what thinking is, it does not follow that we are inevitably condemned and limited to the use of introspective approaches only. Perhaps another physiological conception is possible.

Let us get back to a larger view of the man with whose thinking we are concerned. Let us contrast his more rational activity with his behavior when he is suddenly beside himself in anger or in fear, or with that of a child or an ape. In the former case we observe the sculptured thinker again, with his apparent immobility. In the latter we see much activity, hit-or-miss, pull-and-tug, try-try-again behavior, an improvident expenditure of energy in explosive and random and ill-guided movements. In one case our man solves his problem with little apparent preliminary reactions at all; in the other the visible slashings about are an integral part of the solving process and success generally comes to him who is most persistently active. Now, it has long been an axiom that these two cases are but extremes in a gradation. The apparently inert attitude of philosophic reasoning, and the persistent activity of the paramecium repeatedly backing off from the drop of acid to turn itself a little to one side and renew its forward trials, are but the highest and the lowest varieties of the struggle of living creatures to surmount their obstacles. They are both trial-and-error types of response.

If we recognize this continuity, our traditional way of conceiving thinking as an intracerebral performance becomes anomalous. If the try-try-again is originally a matter of

motor trials *via* complete sensori-motor arcs, how does it come about, and just when, that the scene of the try-try-again becomes shifted from these motor organs and these arcs to merely intracortical association paths? Is there a sudden, distinct stage when trial and error behavior manifests such an obvious change that all varying and selecting *before* this can be considered as of muscles innervated through connections with sense organs, but *after* this as of central connecting paths only? A negative answer is the only one possible to any one who has observed, for example, subjects attacking problems of varying types: puzzle boxes, mechanical mazes, paper mazes, analogies tests, sentence completion tests, card sorting, memorizing syllables, memorizing stories, mixed directions tests, etc., etc. All degrees of explicitness of movement are externally noticeable in these different cases; and the careful self-observer can report shadings in the 'feel' of the particular 'tries' all the way from the various sensations associated with overt manipulation, through the kinesthetic sensations of sudden muscular strains when pronounced overt action is inhibited, to those feelings of spiritual activity analyzed by James into 'a feeling of bodily activities whose exact nature is by most men overlooked.'

If, now, we recognize that the process of thinking differs from any other trial-and-error activity mainly in degree of explicitness, are we not presented with another physiological conception of thinking, an alternative to the intracerebral conception, the poverty of which I tried to show a few minutes ago? Actions, we know, may and do occur within the human frame without being readily perceivable by one's fellows—actions, I mean, not merely of chemical and biochemical sorts but of muscular and glandular sorts—actions, moreover, of such striped skeletal muscles as move the fingers and arms and eyes. Consider, for instance, the tonicity of the body's musculature, that tension found persistently present but waxing and waning in subtle degrees, changing continually for the whole musculature in general, and more especially for different muscle groups, all this dependent upon nervous innervation, in turn dependent upon the continual sense organ excitation.

Consider also, more isolable, occasional phenomena such as the tightening of the throat in a moment of surprise, clenching of the teeth when one is vexed, excessive salivary flow at the smell, real or imagined, of appetizing food, the unruly heart in moments of controlled emotion, the pulling of muscles everywhere as the abscessed tooth pains us, the shallow breathing when attention is held, the sudden excess activity of intercostal muscles when one's job is done, the straining of arm and leg as we watch the pole vaulter clearing the bar. Such instances are legion, and they serve to show how truly action and reaction, stimulation and response may go on under the skin of a man and not be evident to his neighbor at all. Nor are they limited to the so-called affective and emotional responses, for we find that both visceral and skeletal effectors participate, and they arouse proprio- and some exteroceptors as well as interoceptive mechanisms.

The introspective evidences of the striking part played in the experiences of a man while thinking, by these subcutaneous and non-environmental sensori-motor adjustments and readjustments, have long had their place in our literature. I need quote only two such different but such accurate self-observers as James and Titchener.

"In attending," says James, "to either an idea or a sensation belonging to a particular sense sphere, the movement is the adjustment of the sense organs, felt as it occurs. I cannot think in visual terms, for example, without feeling a fluctuating play of pressures, convergences, divergences, and accommodations in my eyeballs. The direction in which the object is conceived to lie determines the character of these movements, the feeling of which becomes, for my consciousness, identified with the manner in which I make myself ready to receive the visible thing. . . .

"When I try to remember or reflect, the movements in question, instead of being directed towards the periphery, seem to come from the periphery inwards and feel like a sort of withdrawal from the outer world. As far as I can detect, these feelings are due to an actual rolling outwards and upwards of the eyeballs, such as I believe occurs in me in sleep, and is the exact opposite of their action in fixating a physical thing. In reasoning, I find that I am apt to have a kind of vaguely localized diagram in my mind, with the various fractional objects of the thought disposed at particular points thereof; and the oscillations of my attention from one of them to another are most distinctly felt as alterations of direction in movements occurring inside the head.

"In consenting and negating, and in making a mental effort, the movements seem more complex, and I find them harder to describe. The opening and closing of the glottis play a great part in these operations, and, less distinctly, the movements of the soft palate, etc., shutting off the posterior nares from the mouth. My glottis is like a sensitive valve, intercepting my breath instantaneously at every mental hesitation or

felt aversion to the objects of my thought, and as quickly opening, to let the air pass through my throat and nose, the moment the repugnance is overcome. The feeling of the movement of this air is, in me, one strong ingredient of the feeling of assent. The movement of the muscles of the brow and eyelids also respond very sensitively to every fluctuation in the agreeableness or disagreeableness of what comes before my mind."

Or, hear Titchener: "I am sure that when I sit down to the typewriter to think out a lecture, and again to work off the daily batch of professional correspondence, and again to write an intimate and characteristic letter to a near friend,—I am sure that in these three cases I sit down differently. The different *Aufgaben* come to consciousness, in part, as different feels of the whole body; I am somehow a different organism, and a consciously different organism. Description in the rough is not difficult: there are different visceral pressures, different distributions of tonicity in the muscles of back and legs, differences in the sensed play of facial expression, differences in the movements of arms and hands in the intervals between striking the keys, rather obvious differences in respiration, and marked differences of local or general involuntary movement. It is clear that these differences, or many of them, could be recorded by the instruments which we employ for the method of expression, and could thus be made a matter of objective record."

It is such screened activities as these, largely hidden away from fellow men, that I propose our exalting to the central place in our physiological description of thinking. What is going on in the thinker is not a shifting and reshifting to and fro, from point to point, in the cerebrum of temporarily imprisoned nerve impulses; it is a prolonged story of minimal but actual adjustments and readjustments of motor organs out in the body.

Let a stimulus of any kind you will excite reflexly some change of tension and of posture in these organs; they will return their appropriate kinesthetic, organic, cutaneous, and other afferent impulses to the central nervous system; these sensory impulses will suffice to awaken reflexly further adjustments of the muscles and glands; these new reactions again arouse afferent impulses to travel to the centers; once there they re-excite the motor organs; and so on and on, until, perchance, some one resultant pattern of activity of the motor organs may meet no hindrance or block and the energies previously interchanged so rapidly between center and peripheral organs may now be expended in outward channels as the thinker apparently comes back to life and plunges into activity. If we could permit ourselves the hackneyed comparison of a man's neuromotor organization with a city telephone system, we might ask whether the real telephone

business of the town is done by the 'hello' girls, who merely plug in the connections, or is done by the subscribers at transmitting and receiving ends.

Well! As a general story you may find this description intelligible; you may even consider it platitudinous. What I propose, however, is that we consider it the basis for the future physiology of thinking.

One great advantage, surely, it would have over the description of thinking as a purely cerebral performance. I was trying to show a while ago that to conceive of the manifold changes of one's thought as based upon (or perhaps as consisting of) changes occurring intracortically is to remove the latter hopelessly beyond our experimental analysis and verification. But to conceive of them as a matter of changes in muscles, glands, sense organs, and peripheral nerves, as well as in the central switchboards, lays them open to experimental approach. As in one of the quotations I have given, they "could be recorded by the instruments which we employ for the method of expression,"—the automatograph, galvanometer, pneumograph, and so on, with of course the tridimensional analyzer, laryngeal sound recorder, etc.

Let me anticipate an objection here. "But these instruments," you say, "are designed for observing affective and emotional changes. Are you not confusing intellectual processes with emotional, cognitive with the affective?" I would answer that what these instruments really record are first of all physiological changes, involuntary changes of skeletal and visceral motor organs. We may call them emotional, or affective, or intellectual, or volitional, as it pleases us; they are primarily such and such bodily phenomena. If time permitted, I would like to expand the point of view lurking in these remarks. I would like to criticize that habit of thought that has flourished in modern psychology as in so many other fields of natural science; that of taking distinctions once made for some particular convenience and exaggerating them into hard-and-fast, dyed-in-the-wool differences. This, I believe, is the logical confusion at the bottom of our distinction between the affective and the intellectual. We may not, however, follow this thread further at this time.

In the physiological description I have suggested for thought there are implied some challenges to further work. There is the challenge to make this decidedly very general description a more definite one on the experimental side by patient determinations of just how different patterns of cardiovascular, manual, vocal, lingual, ocular, etc., reactions function in a man's thinking performance. This sort of program is, needless to say, in the lap of the future.

There is another challenge or responsibility which we cannot evade. It must be granted by the most behavioristically inclined that whatever we know about thinking, further than the identifying of its general occasion and occurrence, we owe to those who have labored descriptively in the analysis of what one experiences when he is thinking. And if one physiological conception of thought claims preference over another, it is fair enough to demand that it make its claim good by demonstrating the bodily phenomena which are the objective bases for their findings.

On the intracerebral view there are practically none. I have said that we know too little about what goes on in detail inside one's brain alone, and we seem destined to learn little more. But on that view of thinking, that makes it nothing other nor more than a complication of sensori-motor adjustments, an interplay of *whole arcs*; a substantial array of principles from experimental physiology lie ready to our hand. Let us, then, first canvass the field of experimental analysis of our thinking experiences to determine the outstanding achievements there. We may then turn to see whether explicative principles may be had from the physiologists.

The general pattern of thought, the general order of one's experiences as he thinks, is recognized on all hands as being of *some* problem-solving type, *some* exploratory searching about for clues or answers to a difficulty. "Necessity is the mother of invention," whether this 'necessity' be born of interest in the recondite musings of a metaphysician or of the desire to obtain a meal, and invention, if it be anything, is the process of looking about for the necessary means for settling the question concerning the musings or the meal. Variation and Selec-

tion, those key principles to the mechanism of natural development of rivers, of organisms, of social institutions, of individual habits, and of thoughts, here operate as clearly as anywhere. When we think or truly reason about a thing, we find ourselves groping, seeking, considering this and that, pondering one thing and another, until, perchance, some one thing, some special point of view, strikes our fancy, seems to serve, and is adopted as our answer to the theoretical query or the bread-and-butter urge. Dewey's analysis of this is widely quoted. The difference once felt will, if it is attacked rationally, be analyzed and defined; suggestions of possible solutions then occur to us; we follow out their bearings, and when one is found good, we adopt it as our answer to the problem.

This type of description is rather general. The experimental work of the analytic psychologists may be considered as the working out of the details, whether or not they have had in mind the same general outline. Let us take the findings of the experimentalists on thought, their key ideas, and see whether we may find ample justification for setting down thinking as a peripheral-central-peripheral process rather than purely central.

Let us start with 'the idea.' This is to take the bull by the horns!

'Idea' has had a varied history and a multiplicity of meanings we need not here detail. The most accepted use of it nowadays is to refer to the image with its meanings, to an imaginal or perhaps sensorial content with its imaginal, sensory, or affective context.

This analysis of the 'idea' into two aspects, the imaginal content and the meaning, leaves us with two things on our hands. Now, as to the image: there are those who reject the conventional localization of images in the cortical areas only; there are those who claim a sensational residuum in every so-called image; there are those who maintain that they truly think without any imagery at all. Time forbids our entering this controversial field. What we must confine ourselves to, is that aspect of the 'idea' that is recognized on all hands as the significant and working part of it—the *meaning*. If the

capacity for thinking is anything at all, it is the capacity to deal with things in terms of their meanings. And I would suggest that the concept of meaning is a key one for the psychological understanding of human beings especially.

A recent writer on the subject (Watson) has disavowed any interest in meanings, saying, "We watch what the animal or human being is doing. He means what he does." No! He means what he is *about* to do (if he means at all), or else he *has* meant what he is doing now. What is overlooked is the fact that meaningfulness translated into terms of activity is some tendency, some liability to 'go off.' Have we not here a case of the extreme behaviorist's bending over backward; so insistent is he upon objective phenomena that he recognizes only overt motion and change and not covert alterations in tensions.

In human psychology it is a common enough practice to refer meanings to a perceptual origin. Now, what is perceiving; what is going on when a man is perceiving something? The familiar line of answer by the traditional psychologists is to give a descriptive analysis to that of which one is aware when he is perceiving. Thus, much is made of the evidence of an analytic as well as a synthetic activity of 'the mind,' also of the additive, interpretative activity of the same 'mind.' Surely we can find a more vital and fruitful way of studying perceiving, if we consider it as a human being's way of getting a purchase on this world he lives in, as the way he comes to recognize things as having such and such properties, as being signs of such and such. A complete treatment of the topic of perceiving is made far more possible by this objective way of description than by a subjective one.

For instance, let us consider, somewhat after Dunlap, the development of a child's perceiving of a seen stick of candy as a delectable edible. This is describable in terms of a process as simple and as objective as conditioning. Let us assume that Billy Boy manifests a tendency to reach out, whenever so definite an optical stimulus as this red-and-white striped rod is presented not too far distant. The original behavior may then be described as the 'candy-seen' arousing the 'reaching-

out' reaction only. But let the candy be seen and handled and tasted and smelled a few times, and thereafter the behavior becomes a matter of the 'candy-seen' arousing the complex reaction of the 'reaching-out' and 'palping' and 'licking-lips' and 'salivary-flow.' Hereafter, the child *knows* his candy—he can rightly perceive it—for will not its appearance to any sense set up in him all these appropriate responses? A seen stick of peppermint is a good-to-eat thing. Or, take the trite example of the baby and the candle flame. Here the flame stimulus, which originally evokes a reaching-toward response, comes to arouse the antagonistic one of withdrawing; and the seen flame now has become a to-be-avoided thing. Any stimulus can in this way gain power to arouse a complex response. Now, of course, these responses need not be completely followed out, they may be merely initiated, started, then inhibited by the disappearance of the candy or by a shift of the attentive attitude to some other object that starts arousing its own reactions. I can hardly over emphasize the importance of this point, that a nascent, just-begun movement or secretion is still a genuine reaction, a somatic or peripheral fact. On the first occasion, our Billy Boy would plump into full and complete activity as obvious as you could desire, but the restrictions placed upon his movements by the inconvenient parental environment might early arouse inhibitory tendencies serving to keep his grasping-sucking-salivary reactions from full appearance, and only the eye of scrutiny could tell us that they were there at all.

Change the situation a bit. Let the obstructing parent disappear, and it is altogether likely that our young subject will show a releasing of the inhibitions in the joyous explosion of seizing and devouring. Clearly, then, the abbreviated conditioned reactions we have noted as the essentials of his perceiving may serve also a preparatory function. The sight of the food does, as we all know, excite salivary and even gastric glandular responses in anticipation of the actual biting and swallowing of the food.

It is my thesis that such abbreviated, anticipatory reactions aroused by a thing *are* that thing's *meaning*. I need

hardly remind you of the way in which children find meanings in things, largely in terms of their own activity. So with sophisticated adults too, in many obvious ways. Some one has said: When a farmer in a year of bumper corn crop and high-priced coal, scoops corn into his furnace, it is clear that for him the grain has now the meaning 'fuel'; and when you have pushed back from the table and lighted your cigar, it is obvious that for you now a convenient saucer has lost its 'cup-and-saucer' meaning and assumed an 'ash-tray' meaning. That is what you are doing or are about to do with it.

And now! What is the difference between this 'doing' and this 'being about to do'? Surely it can be only a difference of degree. How then can we continue to think of a man's voluntary dealing with a thing as a complete response with its sensory-central-motor phases, but think of his perceiving it as only a central activity locked up in his cerebrum? Is it not far simpler to regard the meaning-without-overt-activity as a matter of reactions actually occurring, but minimally and unnoticeably? Meanings must then be actual somatic (or visceral, or peripheral) settings, and accordingly not a mere matter of intracortical exchanges of association impulses.

Etymology lends support to this active or rather reactive view of a thing's 'meaning' to a person. 'Apprehension,' 'comprehension,' 'grasping,' 'taking in,' 'sizing up,' etc.—what are these all but words revealing the more primitive origin of our more sophisticated dealings with things; as primitives we seize, or finger, or manhandle things that interest us; as sophisticates we do this only implicitly, with nascent and abbreviated actions.

"Before he is a substance, the sun is a god." Santayana's words may remind us of the further point that not only is the meaning that a thing may have for you a matter of just what reactions it may excite, of hand, or eye, or voice, overtly or implicitly, but it is also a matter of the so-called emotional-affective responses. The hackneyed phrase should be reread, "Nothing is ever good or bad but visceral responses make it so." In the illustration of the baby and the candle flame

given a while ago, as well as in that of the perceiving of candy, the visceral and other involuntary responses aroused form a striking part of both stories in ways so obvious, surely, as to require no elaboration.

A thing's meaning, we may sum up, is constituted of the motor-emotional reactions aroused, whether completely called out, or whether merely aroused, but held in check and largely hidden from a neighbor's curious eye. And we are now in a position to return to our original question as to a physiological description of the process. Is meaning an intracerebral change and interchange of neural impulses shunted to and fro between the thousands of different groups of cortical neurons? Is it not rather a reaction in the usual and legitimate sense of processes of the complete afferent-central-efferent type? And if we remember that almost any response provides further stimulation arousing or influencing the next response, we can imagine how a long series of such responses of complete sensori-motor arcs may be run off without special tips from the external environment. One reaction-attitude naturally leads into the next, that into the next, etc., for a considerable time, while the man himself may be experiencing it all as the way things seem to interlink and suggest each other.

A word only on 'concepts' or 'general ideas,' that greatest trouble-maker among psychologists for centuries. Once a given object's meaning is seen to be reducible to the pattern of responses, explicit and implicit it calls out, we should have no difficulty in recognizing that such a motor-emotive attitude may be set up by many objects indifferently. A child whose acquaintance has been limited to cats is pretty sure to approach any small, tame animal with a call of 'kitty' and a patting response all ready to unfurl itself. Special attitudes and intents toward special subdivisions of this 'kitty' class come as a result of later experience, experience in the form of additional stimuli that serve to check and change this 'kitty' response, especially in the case of barking kitties. The child's original 'kitty' attitude was a general one, but general not on account of any *Uebersächtigkeith*, but because it was arousable by any of a wide range of stimuli.

So much for meanings—which are the data and substance of thought. Turning now to the experimental studies that have been devoted to the analysis of one's experiences while thinking, let us ask what new principles have been brought to light. We must then inquire whether our peripheral-somatic view squares with these findings, whether it is capable of furnishing the necessary mechanisms therefor.

We may note very briefly *die Bewusstseinslage* (conscious attitude), *die Aufgabe* (awareness of the problem), and *die Einstellung* (predisposition).

The first named phenomenon hardly demands prolonged attention from us. 'Hesitation,' 'assent,' 'incapacity,' 'conviction,' 'realization that sense or non-sense is coming,' 'remembrance that one is to answer in sentences,' are a few of the many conscious attitudes reported as a part of the experiences of thinking. But it should be sufficient for us to know that even those who emphasize these findings find them comparable to the feelings of Wundt and the thought fringes of James—and who would deny the widely distributed bodily sources of these?

In the principle of *die Aufgabe* special attention has been called to the preparatoriness of one's mental attitude, to the realization of a problem ahead. And the rôle of this goal idea has been made much of lately. But hear Watt's own description (as quoted by Titchener):

"A preparation that is common to all problems alike consists in a certain adjustment of the body. The observer directs his gaze, more or less attentively, and in a state of expectation that is accompanied by strain sensations of more or less vivacity, upon the screen that conceals the stimulus-word. Now, he will say the name of the problem two or three times over to himself; subordinate idea; superordinate idea; find a part, etc.; perhaps he will think of two or three instances. This process is fairly clear in consciousness at the beginning of the series, and especially on the change to a new problem; but it weakens with time, so that in the second or third experiment the name of the problem is said once only, and finally internal speech lapses altogether and the conscious tension almost wholly disappears. All that remains, therefore, is the adjustment of the body—the fixation of the screen, the approach of the lips to the voice-key, etc.—and a state of faint expectancy."

What is there here that would lead us to anything but a description of the whole thing as a complex of *bodily* attitudes and reactions, in part objectively observable to a discerning

experimenter and in part observable to the subject himself, in the form of feeling-sensations? To use a phrase of Titchener's: "The different *Aufgaben* come to consciousness, in part, as different feels of the whole body." Being set for any given type of problem is, then, a bodily set.

Not different in essence is the *Einstellung* phenomenon. The importance of one's predisposition in such experiments as lifted weights and reaction time is all of a piece with Myers' 'motor attunement' and with the blacksmith's tapping on his forge between blows at the red hot shoe, or with the boxer's constant dancing about even with his opponent quite out of reach. One keeps 'tuned up' and 'adjusted' for the particular job in hand; and this is ultimately describable principally in terms of muscular tensions and tone.

In my limited time tonight I have been able to touch on only a few points in the psychology of thinking, and sketchily enough on them. I have merely sought to show in general terms how the somatic view of what happens physiologically when a man thinks, has much more to be said for it than the more traditional cerebral view. I have dwelt upon the fact that on the former we have made thinking more an object of possible experimental approach with sufficiently refined instrumentation. That view has further been shown to be more consistent with the stimulus-response mode of conceiving all human psychological phenomena. And finally, introspective descriptions to be made by the man who does the thinking, tally distinctly better with the conception of the business as one that goes on in the large regions of the body, rather than in a temporarily sealed-up cerebrum. Thinking thus becomes in a true, and not a rhetorical sense, a matter of a man's actually adjusting himself and his doings. To hold, I maintain, that the brain is the one principal and important locus of the thinking mechanisms in a very peculiar and special way is a wholly gratuitous assumption.

THE FUNCTION OF THE EMOTIONS

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In all discussions of human behavior today, under the dominance of the physiological principle of explanation, the matter of the exciting stimulus plays a major part. While this is true in general, I believe that the matter of the stimuli that excite the emotions has not received the requisite attention for the formulation of a satisfactory theory. The James-Lange theory, for example, is based upon the assumption that the proper stimulus for the emotions is some object, a bear, or storm, or sound that excites directly the bodily response. While such objects, given the requisite amount of experience, do function in this way, there are at least two other major forms of emotional stimulation to which this theory scarcely does justice. Not only are the emotions excited by objects and by situations, but there is also what we may call the sympathetic form of inducing such excitement, and a third form, probably confined to man, that we may call the subjective mode, consisting of excitement through mental imagery and ideas. Let us consider briefly each of these three forms.

Whether there are any objects that have power in themselves independent of all experience to awaken emotions is considered today doubtful. When search is made for the natural, original, excitant of fear, or anger, or laughter, or curiosity, the results are not convincing. Probably experience enters in all cases to intensify if it does not create the result. Darkness, which later is such a stimulus to fear, is not feared by the infant; neither are animals or strangers in the early months. But objects do possess or acquire emotional significance so that their near presence excites, as it were reflexly, the bodily reactions which characterize that particular emotion. It should be noted however that just to the degree in which

experience enters into the matter, just so far do cognitive factors play a part. So far as being emotional stimuli is concerned, objects do not remain always the same. A bear is not always a bear, a mouse is not always a mouse, but with increased experience they may acquire, or change, or lose their emotional significance. An object is no more emotionally static than it is conceptually. Now it was for excitants of this type and for this type alone that James' theory was meant to apply. Whereas it is doubtful whether this is even the original, primary form of emotional stimulation. For this honor the second form mentioned above could lay claims with some very good arguments in its favor. As a matter of fact we find numerous cases of emotional excitement where knowledge of consequences, if present at all, is miraculous—not experiential. Perhaps an appeal to this second form of stimulation would help to solve some of these that otherwise appear so baffling.

The sympathetic induction of the emotions by the perception, not of its objective cause, but by the perception of emotional excitement in others, is common both to man and to the lower animals. Its importance in explaining the genesis and development of the emotional nature has never been fully appreciated. In some of its forms it has long been recognized even though it played but little part in psychological theory. A dog, for example, will respond at once to the play attitude in other dogs or even in his human associates. There is little difficulty, as every owner of a dog knows, to get him excited merely by some show of excitement in one's own actions. So also a dog approaching two other dogs fighting responds at once by taking an attitude of potential belligerency. In such cases this emotional excitement is purely sympathetic, that is, independent of the object or situation that would normally give rise to the excitement. It is a commonplace that among certain animals, man included, fear may spread like wildfire, although not one in a hundred may have seen the original cause of the alarm. In all gregarious animals susceptibility to this form of emotional stimulation is especially pronounced.

That the same form of stimulation plays an important part

in the emotional development of the individual is a well founded conclusion. The child's first smile and first laugh are almost invariably excited by the smile or laugh of the mother or nurse, not by the perception of something pleasing or ludicrous. From this beginning up to the moral and social approvals and disapprovals, the real original stimulus is not the objective situation but the emotional expression upon the part of his elders. The objects and situations to which these emotions will later become attached determine the social status and the character to which the individual has attained. So, also, in the lower animals, while here the instinctive and reflex factors are more in evidence, the response to emotional expression in other members of the species is unmistakably present. So far as experience counts for anything, the best way for a chicken to acquire the wisdom of his race, is to act as he sees other chickens acting. And what is true of this one species is true of all the lower forms, and this method is not and cannot be dispensed with, even with the human species.

Nor is the utility of such form of emotional stimulation difficult to see; this sympathetic spread of the emotions is a substitute, and in many cases an excellent one, for the more difficult communication of facts and ideas through language. It promotes coöperation through direct emotional unification of the group, gives to each member of the group the advantage of any individual perception of danger, and through this unification serves as the real basis for common social action.

That this form of emotional stimulation carries over into the human sphere is only too obvious. It forms, indeed, the basis for that interesting and important phase of human activity known as crowd psychology. Human beings like the lower animals may get angry, may be thrown into the most intense and senseless expressions of fear by merely perceiving the expressions of these emotions in others. Curiosity also is infectious as every successful teacher knows, and laughter and a feeling of amusement are heightened by the presence of others showing the same tension. The audience in the theater intensifies the effect of the actors. The show of anger, or fear, or sorrow, or amusement, or the demand for vengeance

by any considerable number of individuals is an emotional stimulus too strong to be successfully resisted by the average unsophisticated individual. To account for the force and directness of this form of emotional stimuli, McDougall suggests that there is a special inlet to each instinct for this form of stimulus. Whether or not this is the correct explanation, the fact of its potency can hardly be disputed.

This form of emotional stimulation in man has both the strength and the weakness of such stimulation in the lower animals. It is direct, powerful, and waits not on knowledge, which in emergencies is the part of wisdom and safety. To insist on becoming acquainted first-hand with the source of the danger before it is feared might well increase the casualties of life to an appalling degree. To refuse to get incensed until we are personally insulted or injured, is to do away with the very foundation of social or group action. To allow curiosity to lie dormant until practical advantages are assured, is to remain to all new enterprises and innovations unresponsive and inert. To enter into emotional experiences as deeply alone as when we are with others, is to be dead to the call for companionship and for united effort. This means for stimulating the emotions, therefore, still has its uses and is still one of the major methods of awakening man to intense emotional reactions.

This sympathetic induction of the emotions, on the other hand, has the same logical weakness as have other forms of custom control. It shows the same blindness, the same unprogressiveness, the same tendency to believe in and be satisfied with the present, the same indifference to the real causal factors, the same dependence upon emotionalism, the same lack of intelligent insight that is characteristic of all custom control. To allow one's self to be excited merely because one's associates are, to fear only because others fear, or to be angry because others are enraged, may sometimes be the part of wisdom, but it may also at times be the part of supreme folly. Whether I am justified in my anger, or fear, or enthusiasm, depends not upon its presence or intensity in others, nor upon how many times it has been thus passed from

one individual to another, but upon the original cause or situation. The fact that an emotion has been thus passed on from one individual to another a thousand times can never serve to purify or to justify what was originally absurd, or irrational, or extreme. The fact that it has been thus passed on directly and unpurified means rather that the original weakness or viciousness remains and is intensified and multiplied by this rapid means of propagation. Crowds, therefore, are often capable of actions more extreme, more irrational, more immoral than are the acts of men in their individual capacity. Let the fires of any emotion be fanned by strong emotional expression in others, and this community of feeling is often mistaken for logical justification, and mere intensity for moral justification. Of the extremes to which such influences may lead, social psychologies give ample illustrations.

But we are interested here primarily not in the actions to which such emotional contagion may lead, but in the fact that we have here one of the principal forms of emotional stimulation. Considered either as a factor in the emotional life of people today, or traced back to its earlier manifestations, it has an equal right with the objective form to be regarded as basic. A psychological theory of the emotions to be satisfactory therefore must do justice to this form of excitation no less than to the latter type.

But our enumeration of data concerning the stimulation of the emotions is still incomplete so far as human beings are concerned. The other group of facts that must be recognized and given its place in our theory relates to what we have called the subjective excitement of the emotional consciousness. This class of stimuli has been strangely neglected by psychologists. Perhaps if it had been considered in discussions of the emotions, the theories we have had would not have been so inadequate. Ideas, concepts, images become saturated with an emotional content no less than do objects. As a consequence, the presence in the mind of such ideas is followed with an emotional accompaniment no less directly, and sometimes no less potently, than follows the perception of the objects themselves. Emotions may be excited by all forms of pre-

sentative experience, but they are also aroused by the various forms of representation. It would be difficult to find any one of the principal emotions to which man is subject that cannot be aroused as effectively by ideas as by objects. Memory not only brings back the bare facts of life, but it enables us to live again its joys and its tragedies, its victories and its defeats. In other words, its magic is no more cognitive than it is emotional. To recall scenes of childhood, the old swimming hole, or the old oaken bucket, or the image of a face that is gone, or the sound of a voice that is still—who would say that these are exclusively or even primarily cognitive acts? But it is in the imagination that we seem to find the principal agency for the reawakening of the emotional reactions. Less than human and inert, indeed, is that mind that cannot through the imagination transform some innocuous incident into an insult, and thus give rise to burning anger. And how often is some mere incident, some slight noise when the nerves are tense, transformed into a dire peril, and appalling fear results! Or who would care to assert that the greater share of the emotions that the lover feels, come from the perception of the maiden, and not from the visions and the dreams and the imagery that he sees best when he is alone? Real wrongs are a potent cause of anger, but fancied ones are hardly less common or less potent. Again, it is not adulation or success or honors alone that engenders pride and inordinate conceit; it is thinking about them, reflecting upon them, playing with the thought of one's greatness that chiefly causes its overdevelopment. One of the proudest men I have ever known was a half-wit whose chief cause for pride was the fact that he could live for half of the time on his own resources outside of the county farm. Thought, playing around even the most trivial object or circumstance, can do wonders in magnifying it into a first-magnitude emotional stimulus.

It is not necessary to refer to cases of morbid sentimentality to illustrate the emotional effect of ideas and mental imagery. Illustrations and examples are at hand in every direction. In fact, every idea that has any significant history or content acquires not only a conceptual content or meaning

but an emotional one as well. In many cases, and for some purposes, not the conceptual but the emotional is of greater moment and importance in the life of the individual. The two phases of this content of ideas can no more be separated and kept distinct than they can in our dealing with objects first hand. If either has primacy back in the earlier stages, it would seem to be the emotional, not the conceptual. Especially is this true of the signs used by the lower animals. Danger signals are here one of the most common forms of communication and these are plainly far more emotional signs than they are descriptive symbols. The cluck of the hen will send her brood scurrying to cover, although so far as can be seen she gives them no clue as to just what the danger is. Or another call of a little different quality means food, but the menu she never announces. In the long ages of mental development emotional reactions long served the purposes of life before knowledge based on experience could have pointed out the way.

But as the child with his greater capacity to absorb experience and to understand it grows, this development is both conceptual and emotional. Not a few of the terms of childhood are more definitely emotional than conceptual. 'Bugaboo,' 'hobgoblin,' 'bugbear,' 'hoo-doo,' for example, have no clear conceptual content, but they do stand for something to be feared. I am sure that for years during my childhood 'mad-dog' was not primarily a case of hydrophobia, so much as it was an awful terror lurking in divers places and waiting only to communicate to me that dreaded disease. And in maturity we have a long list of terms whose real significance is as much emotional as it is conceptual. Such, for example, are the terms 'mother,' 'home,' 'country,' 'traitor,' 'liar,' and the like. To say that the significance of these terms is wholly conceptual is simply defective analysis, and to ignore their rich emotional content is to fail to consider one of the important forms of emotional stimulation. When we consider what a small part this factor has played in psychological discussion of the emotions, it is little wonder that psychological theories sometimes seem so aloof from life, the actual,

pulsating, life that men really live and are interested in. Language, therefore, we conclude, begun probably as mere emotional symbols, has never lost this character or function. But just as there is a gradual and constant enrichment of our vocabulary conceptually, so is there with many of our terms a similar growth in their emotional significance. The net result of this enrichment is that language, and the imagery it implies, becomes a marvelous instrument not only for the communication of ideas but also for the orderly and systematic stimulation of the emotional consciousness.

There is one further point to be considered before we pass on to notice the significance of these facts for a theory of the affective consciousness. This point relates to the method by which ideas thus excite the mind to an emotional reaction. Does the stimulus of a given concept act directly by means of its emotional associations, so to speak, or indirectly through the stimulation of the imagination? The correct answer would seem to be that it operates in both ways, although the latter method is by far the more important. Some terms, as we have seen, acquire a pronounced emotional character and something of this is sure to come to consciousness whenever the mind dwells upon them for many moments. Thus the term 'Liberty,' for example, is something far more, and richer, than its deepest conceptual content will explain. Dwelt upon, it brings also a rich halo of feeling, the emotional residue of past experience of a pronounced affective character. Such terms, it is evident, depend for their emotional effectiveness upon the associations they may have acquired in the experience of the individual. But these associations are both conceptual and emotional in their content. As a consequence of this accretion of meaning and of feeling, language will show variations in emotional poignancy upon different individuals. Language is only symbolic and the reaction depends chiefly upon the subjective reaction. But such terms do have direct emotional associations.

The other means of exciting the emotions which language possesses, namely, through its symbolic representation of objects and situations and the consequent activity of the

imagination, is the chief source of the emotional power of language. The cry of 'Fire'! has an emotional element, but 'Your house is on fire' has both a more specific meaning and a resulting greater emotional significance. 'War' has for those who were in the trenches a definite content, but it has also its horror. But war in the abstract is one thing, while 'Our country has declared war' is quite another. Through this descriptive power of language, situations and events can be so symbolically expressed that the imagination pictures them as hardly less than real. Mark Antony's oration over Cæsar may be cited as a classic example of the power of language to excite the passions of men and to lead them on to action even of the most violent nature. But why mention any one case when every drama, every novel, every oration of consequence derives its power and chief function from this primary fact. In these forms language, just because it can thus excite and control the emotions of men as well as guide their thoughts, is the medium for one of the most common and most powerful of the arts.

Language is thus a remarkably effective substitute for experience, but the substitute approaches the reality in emotional effectiveness in proportion as the imagination responds and vitalizes and vivifies the schematic outline that the words at best only suggest. To have a keen, active, vivid, imagination is to have a strongly emotional nature; to have a weak, sluggish, meager capacity for visualizing the ideas language gives, to be engrossed too much with their meaning or philosophical significance, is to be emotionally unresponsive. To be emotional, therefore, is to be imaginative. The two terms are practically synonymous. Just how far language will be effective as an emotional stimulus, therefore, depends primarily and chiefly upon the imaginative response of the listener. Moving pictures are the mechanical substitute for this subjective response, and their power and effectiveness testify to the truth of our contention.

The reason why the emotional reaction to language is so closely related to imagination is fairly clear. Imagination is the power to represent, or to picture in consciousness the

concrete realities of life, both objects and situations. In this process, therefore, we come nearest in representation to the actual first-hand experiences of life. It is, so far as details are concerned and so far as sensuous factors can be made to reappear, the mind's best substitute for life itself. Abstract conceptual thought may see further and deeper into the secrets of nature, but thought is an abstraction and so is inattentive to many of the concrete facts of experience. Moreover imagination, because it can be productive as well as merely reproductive, opens the way for situations that are contingent and ideal, not always actual and real. In this way the emotions not only gain in purity and ideality but by either a proper or improper supplementation gain appreciably, sometimes excessively, in intensity.

Let us see now whether there are any suggestions in the facts to which we have called attention for a psychological theory of the affective consciousness.

We note, in the first place, that the facts given are not on the whole favorable to the James-Lange theory. At its best the theory covers only a limited portion of the data that should by rights be considered. The stimulation of the emotions by objects and objective situations is only a part of the story. Central factors apparently do play a part in the matter. Furthermore, to make the emotions epiphenomenal in character and in futility is something out of harmony with the universal connection that seems to obtain between feeling and action. While some have agreed to disregard consciousness altogether in their explanations, the experiment is a good deal like tying a man's hands and feet and urging him to swim; he may succeed but it is idle to say that he is not handicapped by the treatment. Nor is the fact that as yet we are unable to explain the process by which consciousness can effect bodily control, fatal to the conclusion that it actually does so. Upon this basis we would have to deny the efficiency of gravity, of chemical affinity, and any number of physical forces that are accepted in good faith by scientists everywhere. Better will it be, therefore, if the facts seem to warrant the conclusion, frankly to accept the theory of the utility of

consciousness, admitting ignorance where we must, and try as best we can to find a theory that will meet satisfactorily the conditions as they exist.

The principle of utility or adaptation in biology has since Darwin, and even back to Aristotle, been regarded as a basic principle of interpretation, and has abundantly justified its use in this direction. In fact it is difficult to conceive of the confusion and disaster that would come to this science were this principle to be disavowed. But if its use is justified in that science in regard to both structure and function, it is difficult to see how or why it should be excluded in this closely allied sister science.

The second class of emotional stimuli to which we have directed attention, direct emotional infection, is also illumined and given meaning by this same principle of interpretation. Here also the fact of utility is too obvious to be overlooked by the unbiased observer. To enter into the emotional excitement of other members of the species even when the originating cause of the excitement is not perceived or known is a principle of daily utility to thousands of forms of animal life. The animal of purely individualistic traits may, through sharper wits and keener sensibilities, manage to survive and prosper. But to utilize the reactions of others and not to wait to perceive the source of the danger is for animals with limited means of defense a protective device of a high order. Moreover, it is difficult to see how upon any other basis than this of direct communication of emotion, group action of any sort could have been possible where language did not exist. A consideration of the action of a herd of cattle or of McMillan's musk oxen in time of danger and of attack will justify this conclusion. If social or group action and united effort is at times desirable, if social development is, in fact, one of the great lines of evolutionary development, if sympathy and helpfulness are really virtues, then this direct communication of emotion is a form of emotional stimulation that bears rich fruit in the practical everyday business of life.

Our first comment upon the third group of facts given, the excitement of the emotions through the medium of ideas and

of imagery and of thought, is that whatever may have been the function of feeling in the lower orders and stages of life, it was too important to be left behind as higher powers of cognition developed. The fact seems to be that in every stage of mental development, from the lowest to the highest, there has been the closest correlation and interdependence between the cognitive and the affective consciousness. True enough the affective element in the higher reaches of thought does not have the same drive and impulsion that it has in the lower. But the crises in the thought realm hardly bear so directly upon survival and immediate well-being as do objective situations. The appreciation of beauty, however, the desire for logical unity and congruity, is with some a desire strong enough to have borne some very choice fruit in the realms both of science and of art.

A conclusion impressed upon us throughout our discussion is *the unity of function of knowledge and of feeling*. They are true supplements of each other, so that they are useless each without the other. When desire fails, knowledge is impotent to secure consistent and persistent action. Knowledge, in order to increase, needs the spur of curiosity, interest, to arouse to effort and even to attention. Keeping young—and youth means action, striving, doing—is a matter of keeping the emotions and the desires of youth. The relation between these two aspects of consciousness is constant, unvarying, because it is organic, constitutional. Whatever therefore may be the ultimate function of knowledge, that also is the ultimate function of the affective consciousness. If it be true that sensation, perception, memory, imagination, judgment, and reasoning play a real active part in the business of life, so also do pain and pleasure, anger, fear, curiosity, as well as the higher ethical and æsthetic forms of feeling. Every one of these cognitive processes has its affective component. And what is thus invariably and consistently present, is causally and organically bound up with the functional activity of that which it so faithfully attends. Emotions are excited, as we have shown, through the same system of sensibilities or through the same representative functions of the mind that

are employed in all forms of cognition. The organic relationship between these two forms of consciousness accepted as a fact helps us to understand their Siamese indivisibility, and it serves in turn as a basis for a new inference or conclusion.

Now it is customary in these pragmatic days to say that all knowledge is for the sake of action. If so, and if our previous conclusion is a valid inference from the facts, then the emotions exist also for the sake of action. In some way, whether psychologists can give the *modus operandi* or not, the emotional consciousness does play a part in determining conduct.

And yet, while it is true as we have asserted that the ultimate end of the cognitive and affective consciousness is the same, nevertheless they must each have their own specific function, else there would be no purpose for their differentiation. It is more particularly this specific function that is sought by those interested to understand the psychology of this aspect of the conscious life. Let us see whether we can find any suggestions in this direction that not only accord with, but will serve to interpret the facts before us.

There is in mere knowledge a weakness, a defect, noted long before the days of Pragmatism and Behaviorism, but which these two movements have served further to emphasize. Knowledge for knowledge's sake is an ideal as pure and as impotent objectively as Berkeleyanism. The only Truth that can make us free is truth that is put into action. Knowledge as knowledge is subjective, contemplative, inert. What is needed for the practical life is some way of transforming this into action.

This defect of knowledge is remedied through the affective consciousness. It is redeemed from its subjectivity, its epiphenomenal character, by the dynamic of its feeling component. There is in all emotion a drive toward objectivity such as is not found in knowledge *per se*. Neutral sensations, if there are any such things, leave us passive, unmoved, but the emotions are an inward impulse to action and to objective expression. The subjective, Platonic, ideal of philosophical reflection as an ideal is defective, incomplete unless supple-

mented by the romantic ideal of feeling and of action. Neither aspect of the conscious life is able to stand alone. The emotions must be purified, harmonized, shown the better way by thought, and the idea must be quickened, vitalized, given a drive toward objectivity by the emotions. Otherwise it fails to connect up with life and is open to the charges and criticisms that have been leveled against the various forms of subjectivism. It would not be far from the truth, therefore, to say that the function of the affective consciousness is that it serves as a means of raising the cognitive consciousness to a working potential. Information that such and such consequences follow such and such conditions may be practical, useful knowledge or it may be nothing more than a state of subjective certainty. Whether it will be the one or the other depends upon the presence or absence of an emotional accompaniment.

When it is realized, moreover, that the emotions are characterized by a drive toward objective expression, and that the body is the instrument through which mental states must be objectified, it is not surprising to find the most intimate and thorough-going relationship between the emotions and the bodily organism. And this is, as a matter of fact, the sum and substance of no small part of recent investigations of the emotions. In order that the emotions may find the proper means of expression in action, the whole body must enlist for service. And this is the condition actually found. Not only the musculature but the various systems—the circulatory, the respiratory, and the various glands of the body all are involved—all contribute. Darwin was on the right track, therefore, when he looked for and found utility in the various forms of emotional expression. Not only do the emotions find expression in bodily action, but it is of their essence so to do.

In this respect there is a striking contrast between the affective and the cognitive consciousness. A strong emotion reverberates through the whole bodily organism and is characterized by an unmistakable impulse to action. Knowledge, on the other hand, that is free from this affective factor

too often leaves the body impassive. Knowledge as mere knowledge needs little in the way of motor expression, or if it is urgent that it be expressed in action, this result is obtained by an increase in the emotional potential. So far as we know at present, the bodily correlate to cognition is confined largely to the higher association centers of the cerebrum and does not pass over automatically to the centers of motor control. But knowledge, to be objectified or utilized, does demand this further motor excitement. A mere belief that a new world existed beyond the western seas might have existed in the brains of many of Columbus's contemporaries without producing results in the objective world of affairs. But in the mind of Columbus this belief assumed a strong emotional component in the form of conviction and a desire to discover this world or way. In this form it could not remain a simple belief, but must find expression in action, enlisting for this purpose the full resources of mind and body. Even the most positive knowledge unless fired with emotion leaves the individual strangely unresponsive and inert. Thus it is possible to point to a considerable body of physical modifications as characteristic of the various emotions, but to do the same for various forms of cognition is a task that has never even been attempted. Knowledge becomes practically efficient, a power in the lives of men, only as it assumes the drive, the inward push toward expression that is the affective consciousness.

The means by which matters of simple apprehension or of a more abstract conceptual content are transposed into objective realities is through a preferential rating in consciousness. Some acts and ends are felt as desirable, some as undesirable; that is to say, some have this inward urge toward realization or continuation; some have just as definite a drive in the opposite direction. In the earlier stages of mental life this must have been confined to the mere pleasantness or unpleasantness of stimuli. But pleasantness is equivalent to, if not synonymous with the fiat, 'Let it be,' and painfulness to the fiat, 'Let it cease.' One is constitutionally and inherently promotive, the other inhibitive. Pain and pleasure, therefore, are the first criteria of value, the one urging toward avoidance of the stimulus, the other toward its continuation.

But it may be asked, what need of this mediation of consciousness? Why not the simple fixation of stimulus and response such as we have in simple reflexes? The obvious answer is that in a complex environment where stimuli are multitudinous in number, variety, and intensity, such a complex of reflexes, all adapted to a common end, the welfare of the individual, is too great a complication even for the profoundly complex nervous system. Pain and pleasure are a means of simplification of integration of reactions that can be and have been utilized throughout the whole course of evolutionary development.

Simple sensations, however, with their attributes of pleasantness and unpleasantness, while primary and of such importance that their utility has never been outgrown, do not suffice to meet the conditions of higher forms of cognition. Certain stimuli remain either pleasant or painful, but as the mind develops the capacity to react not merely to stimuli but to *objects* and to *situations*, such simple affective machinery would not suffice. The apprehension of objects is a new condition and demands new measures. It marks, in fact, a tremendous cognitive advance and demands an epoch-making modification of the affective component of consciousness. Objects cannot be evaluated by the simple sensations to which they give rise. Dangerous objects are not always sensuously irritating nor are all pleasant stimuli indicative of wholesome objects. But even to wait here for experience to testify in the matter would be too costly. In many cases the first experience would prove fatal and the lesson would be lost. With such a method the percentage of casualties would be so high that it would tax even Nature's generous system of reproduction. To meet this situation, therefore, some new method of evaluation was imperative.

It was at this stage of cognitive development in all probability that the emotions had their origin. Fear, for example, can be aroused when there is nothing painful or irritating in the stimuli exciting it. Such in the great majority of cases is probably the case. The breaking of a twig, the odor of a man, or the sight of a wolf are hardly directly painful to a deer, but

through the fear aroused they are nevertheless effective in securing definite and vigorous action. Of the process by which certain objects and situations have acquired emotional significance we are still very much in the dark. An appeal to experience would leave us two methods that together would meet the great majority of cases: namely, experience that results in pain or pleasure for the individual, and second, the method given under our second class of stimuli. The method of conditioning also promises well.

Whatever the method, however, it is true beyond question that the emotions, no less than sensory pain and pleasure, give value to experience both positive and negative, and thus serve as a principle of selection and of motivation. What we fear, we would avoid; what we are angry with, we would injure; what we are curious about, we would examine; what we are disgusted with, we would leave severely alone. The source of the greater value that the mother feels for her own child is subjective, not objective; it is in the mother, not in the child. For eyes not quickened by this inner glow of feeling, the outward marks, even if present, fail to bring conviction. It is one of the outstanding mysteries of life, in fact, how emotion will gild some of the common objects of life and give them for the individual transcendent worth. Thus emotion was made to do service for objective value long before cognition was adequate to determine the matter, and in fact long after. Nor is there cause to be dissatisfied with this arrangement. Being subjective, the emotions can reflect an individual need, a demand to meet a present but temporary crisis without that long laborious process that marks the *via cognitionis*.

Furthermore, the emotions are notoriously turned to action. To fear is not merely a subjective state of trepidation, it is also an impulse to definite and vigorous action. To be angry is not merely a feeling of ill will toward a person or object, it is a desire to injure the object of the emotion. To be curious is to be moved to examine, to investigate, to manipulate, the object that has aroused our interest. Whether viewed introspectively or objectively this fact stands as basic. Emotions, in other words, do bear fruit in the practical world of action.

What emotions thus interpreted would mean in terms of brain action is largely a matter of conjecture. Too little is known at present of the exact nature of the nervous impulse and especially of the means of nervous control to state in exact physiological terms just what the various conscious states imply. One or two inferences, however, we may venture to make.

If our hypothesis be correct and the affective consciousness is the means by which the cognitive consciousness realizes itself objectively, the emotion is due largely to central factors, and not to peripheral ones as the James-Lange theory holds. The relation of emotion to cognitive factors is too close to allow of any other conclusion. A bear is not always a bear for the emotions any more than it is for cognition. And what it is emotionally depends upon what it is cognitively. If cognition in its simpler and in its higher forms implies the activity of association centers, then emotion too is dependent upon the same central factors. Artistic education and moral education are the means, and apparently the only means, of giving rise to the real æsthetic and to the higher moral feelings. That is to say, the only way of developing the proper emotional reaction is by opening up the proper associations, enriching the conceptual significance of the object in question. This interpretation accounts also for the fact that objects are not natural stimuli for the various emotions but *acquire* this character and function.

Again, if the essence of the emotion is the impulse to action, or so far as there is a motor factor involved, it would seem to follow that the brain activity would lie between or involve the perceptual centers together with association neurones where the object is perceived and given meaning, and the motor centers where the excitement finds its normal expression. Thus, for example, our bear again. Let him be seen in the woods coming in our direction, near at hand, growling; and as relative to the other party, unarmed, alone, no apparent way of escape, and subjectively, an idea of a bear as a dangerous animal with concrete associations and previous emotional experiences in this direction; and the stage is set

for a real emotion of fear. Here is quite a complex of factors, some perceptual, some more or less cognitive or logical, some revived. And yet they all play a part in the excitement of the emotion. A modification of any one of several of the points suggested would leave the individual unexcited, unafraid. Let the bear be seen at a distance, going in an opposite direction, or the individual be properly armed, or moved by a desire to secure a good picture of wild life, and the emotional result will be something altogether different. Most assuredly the matter is not so simple as it has been pictured, a mere reflex response to a particular stimulus. Instead of the emotion being the sensory aftermath of a group of bodily reactions, does it not seem more in accord with the facts to regard it as the conscious correlate of the stimulation of certain perceptual and association centers having pronounced and direct motor connections? Certainly these are involved in the experience.

We may, I believe, safely take one further step. The two characteristic facts about an emotional experience both subjectively and objectively considered are its *intensity* and its *extensity*. A strong emotion is one of the most intense forms of consciousness and calls forth the most energetic forms of bodily activity. At the same time its extensity is just as unmistakable. Memory, imagination, attention, association, judgment are all profoundly influenced. But the emotion reverberates likewise throughout the whole bodily organism as we are coming more and more to see. Now the nervous correlate or cause of these two phenomena is a high nervous potential. Certainly it is in accord with all that we know of physiology to attribute intensity of consciousness to intensity of nervous impulse. But in the case of emotional stimuli this intensity does not lie ordinarily in the simple sensory stimulus. It must therefore be 'stepped up' in the central transformer to secure the results observed. The same conclusion holds also in regard to extensity of response throughout the body.

By what process, then, the physiological question becomes, do certain stimuli tend to rise in nervous potential, while

others operate smoothly and consistently at low potential? An answer to this question would go far to solve some of the mysteries now so perplexing that hang about emotional phenomena. A possible physiological explanation would be found in the principle of summation of stimuli. Thus every point in the bear situation has in it the suggestion, 'Run'; or in more strictly physiological terms, to discharge down the motor pathway to the center controlling this form of locomotion. This much seems certain: To find the reasons for this rise in potential we must look not outward but inward, not to the incoming factor alone but to central ones that supplement and control the outlet for such stimuli.

To summarize: There are three classes of stimuli that excite the emotional consciousness. First, objects and objective situations; second, the perception of emotional excitement in others; and third, the subjective excitement of the emotions through ideas and images. The third class has never received adequate recognition in formulating a theory of the emotions, which fact may account for failure in this direction. Language is usually regarded merely as a means of communicating ideas, that is, for its conceptual content alone, whereas many of our terms are suffused with emotional significance. There are two ways in which language excites the emotions, (1) by direct emotional association, and (2) through its power to represent symbolically objective situations. In this second method the imagination plays a large part, so much so, in fact, that to have a vivid imagination is equivalent to being emotional.

There has been throughout the course of mental development the closest correlation between the cognitive and the emotional consciousness, indicating a unity of function and a mutual dependence each upon the other. But while they have ultimately the same end they each have their own specific part to play. This specific function of the affective consciousness is to furnish the drive toward objectivity through bodily expression. For this reason there is a closer and a more thorough-going correlation between the emotions and the bodily organism than there is in the case of the cognitive

consciousness. The means through which this drive toward objective expression is realized is through a preferential rating in consciousness. This holds true from simple sensory phenomena up to the most complex forms of the affective consciousness. The emotions proper probably arose concomitantly with the ability to apprehend not stimuli but *objects*.

In terms of brain states, the emotions, under our interpretation, are due more to central factors than to peripheral ones. Associations are as vital for the emotional consciousness as they are for the cognitive consciousness. The particular function of the emotions would seem to be to raise the nervous potential so that immediate and vigorous action is assured.

THE DEVELOPMENT OF BEHAVIOR IN VERTE-
BRATES EXPERIMENTALLY REMOVED
FROM THE INFLUENCE OF EX-
TERNAL STIMULATION

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The behavior of an adult vertebrate differs radically from the behavior of a young individual of the same species. What are the factors which bring about this differential transformation? Is this modification of activity the result of environmentally conditioned learning or of the maturing of certain innate behavior patterns or 'instincts'? The experiments recorded in this paper were undertaken in an effort to throw some additional empirical light upon certain phases of this question.

PART I. EXPERIMENTAL

The specific problem of the present investigation was the determination of the nature and the speed of the process by which developing vertebrates first acquire the ability to carry out muscular movements. The work was done upon the embryos of the frog (*Rana sylvatica*) and the salamander (*Amblystoma punctatum*). A relatively short time is required for the development of these embryos from fertilized eggs into larvæ with well-coördinated swimming movements. The fundamental procedure of the investigation consisted in the comparison of the movements of larvæ which were allowed to develop 'normally' with the movements of larvæ which were reared under such experimental conditions that they showed no gross bodily movements until released by the experimenter.

The embryos used in these experiments developed from eggs found in masses in small pools in the neighborhood of Princeton, New Jersey. In all cases the eggs were in very early stages of cell division when they were brought into the

laboratory. The technique of the experiments, save where noted to the contrary, was the same for both the *rana* and *amblystoma* embryos.

In the laboratory the protecting jelly was removed from the individual eggs. This somewhat tedious process was accomplished by holding a few of the jelly-surrounded eggs upon a piece of very damp paper toweling by means of a wide-mouthed pipette. Then, by the use of needles, the individual eggs were teased out of the jelly. The bare eggs were kept at all times in covered glass dishes filled with tap water. The embryos were allowed to grow in these dishes until the head and tail 'buds' could be observed. Body movements do not appear in these organisms until a stage much later than this early head and tail bud period; indeed at this stage the peripheral nervous system has not developed.¹

The embryos in this early head and tail bud stage were, in all of the experiments, divided into two similar groups. One of these sets, the *control group*, was placed in a development dish filled with tap water. The other set, the *experimental group*, was placed in a development dish filled with a solution of chloretone (chlorbutanol). Previous work had shown that living organisms placed in a solution containing certain concentrations of this drug continue to grow, but they never exhibit any body movements in response to external stimulation while they are under the influence of the anæsthetic.² The present experiments confirmed this observation. Some little difficulty was experienced in determining the optimal concentration of the drug in which to raise the experimental groups. If the solution was too weak the embryos would show some slight movement in response to strong stimulation while still supposedly under the influence of the anæsthetic. When movement of this sort occurred the

¹ Cf. Herrick, C. J. and Coghill, G. E., 'The Development of Reflex Mechanisms in Amblystoma,' *J. Comp. Neur.*, 25, 1915, pp. 67 and 82.

² Cf. Randolph, H., 'Chloretone (Acetonchloroform): An Anæsthetic and Macerating Agent for Lower Animals,' *Zool. Anz.*, 23, 1900, pp. 436-439. Also, cf. Harrison, R. G., 'An Experimental Study of the Relation of the Nervous System to the Developing Musculature in the Embryo of the Frog,' *Amer. J. Anat.*, 3, 1904, pp. 197-220. The writer is indebted to Professor S. R. Detwiler for suggesting the use of this method in the problem reported here.

entire experimental group had to be discarded. On the other hand, if the solution was too strong the embryos developed morphological abnormalities. Typical of such defects was a great bloating of the body which either resulted in death or seriously interfered with later observations on movement. The best concentrations of chloretone for the proper development of the *rana* and *amblystoma* embryos were found to be somewhat different. Good results were obtained with the frog embryos raised in a solution containing, by weight, 3 parts of chloretone in 10,000 parts of water. For *amblystoma* the best results were obtained in a solution containing 4 parts of chloretone in 10,000 parts of water. Acceptable results however were secured in solutions differing slightly from those noted above.

In all cases the experimental and control groups were kept in covered glass dishes on the same table. No especial effort was made to regulate the temperature or the light of the room in which the investigation was carried on. Both the experimental and control groups were thus at all times subject to the same conditions. Morphologically the development of the control and the experimental embryos was, in the best examples, quite similar. In all cases the larvæ in the tap water grew more rapidly in size than did those in the chloretone solution.

At a certain point, as previously noted by Drs. Herrick and Coghill,¹ the developing embryos of the control group began to respond to the stimulation of slight touches of a slender rod. Very soon after such responses had been first elicited, both in the frog and salamander embryos, a coördination of responses was effected which culminated in rapid swimming movements. Similar stimulation elicited no movement in the experimental embryos at this stage or at any other period, so long as the animals lived and were kept in an anæsthetic solution of proper concentration. From day to day these drugged larvæ showed a gradual morphological development; otherwise they were absolutely 'inert.'

In the organisms raised under these experimental con-

¹ *Loc. cit.*

ditions, therefore, bodily movement in response to external stimulation was absent during growth. Long before muscular response commenced in the normal embryo these experimental larvæ were placed in the chloretone solution, and until released by the investigator they gave no evidence whatsoever of behavior.

The method of liberating each embryo from the influence of the drug consisted in lifting it with a pipette from the chloretone solution and placing it in a large dish of tap water. The time after the organism was placed in the unmedicated water until it elicited the first movement in response to the stimulation of a slender rod was taken by the use of a stop watch. The tables given below indicate this time to the nearest minute for the frog and salamander embryos.

TABLES SHOWING THE TIME AFTER REMOVING EMBRYO
FROM ANÆSTHETIC BEFORE FIRST RESPONSE
TO STIMULATION WAS OBSERVED

TABLE I

AMBLYSTOMA

Embryo number.....	1	2	3	4	5	6	7	8	9	10
Time in minutes.....	14	25	9	7	6	8	8	7	24	13

Embryo number.....	11	12	13	14	15	16	17	18
Time in minutes.....	9	9	12	11	5	5	28	8

TABLE II

RANA

Embryo number.....	1	2	3	4	5	6	7
Time in minutes.....	10	14	11	7	9	15	15

The conclusion of the present preliminary experiments is, therefore, that in a period of time which averages less than twelve minutes, embryos raised under conditions of absolute artificial inactivity are able to respond to external stimulation. In varying lengths of time after this first movement, but in all cases in less than thirty minutes, the previously drugged

embryos showed coördinated swimming movements. In fact a number of the eighteen *amblystoma* embryos swam so well in less than one half hour after they had shown the first sign of movement, that they could with difficulty, if at all, be distinguished from the members of the control group who had been free swimmers for five days.¹

PART II. THEORETICAL

May the results of this experiment be interpreted as giving additional support to the theory that the maturing of innate factors alone accounts for the development of the neuromuscular mechanism upon which behavior depends? Certainly the results of the experiments recorded above seem to show that the reflex system of these organisms is able to function in a manner which is biologically useful to the animal in a very short time after the first signs of behavior are noted. But is this rapidity of development a sign that these swimming movements were already determined in the fertilized egg? May we class this behavior with those functions of which Professor Woodworth has written, ". . . the only question, regarding such traits, is whether the environment is going to be such as to enable this young individual to live and mature and unfold what is latent within it"?² It does not seem to the present writer that this 'maturation hypothesis'³ is necessarily substantiated by the facts discovered in the experiments reported above. Much recent work upon the development of the neuromuscular system, as I have shown elsewhere,⁴ points to the fact that the growth of this system can only be understood in terms of continuous living function.

¹ Due to many imperfections of technique in the rearing of the earlier series, the 25 cases tabulated are the only ones, out of the many hundreds originally studied, in which the conditions of experimentation were sufficiently controlled to assure scientific accuracy. The writer hopes to make further studies in this problem in subsequent seasons when the material is again available. The results recorded here upon *amblystoma* as well as upon *rana* confirm in most respects certain observations previously made by Professor Harrison (*loc. cit.*) upon the frog.

² Woodworth, R. S., 'Psychology: A Study of Mental Life,' 1921, p. 91.

Cf. also Gates, A. I., 'Psychology for Students of Education,' 1924, pp. 110 ff.

³ Cf. Allport, F. H., 'Social Psychology,' 1924, p. 44.

⁴ Carmichael, L., 'Heredity and Environment: Are they Antithetical?' *J. Abn. & Soc. Psychol.*, 20, 1925, pp. 245-261.

The intricate development of such interrelated structures as receptors, nerve trunks, central apparatus and motor end-organs appears to be determined by functional stimulation within the organism itself. The excitation and response of the elements of the neuromuscular system is itself a part of the growth process. It may thus be said that during growth these systems are continuously functioning, and yet before a certain stage has been reached they are not able to serve their typical *purpose* in the organism. This of course does not mean that development is a non-functional and a mysteriously teleological event determined alone by certain elements of the original germ.¹ Indeed, as Dr. Child has well said, "The older conception of ontogeny as a process of construction of a machine which, after construction is completed, begins to function seems less and less satisfactory as our knowledge advances. Living protoplasm is functioning at all times and development is a process of functional construction, that is, beginning with a given structure and function, the continuance of function modifies the structural substratum, and this in turn modifies further function and so on."²

It should be remembered, too, that in the experiments recorded above, the swimming reaction was not perfect at the first trial. From the initial twitch to the fully coördinated swimming movements, a continuum of increasingly complex responses could be noted in each organism as it developed through the short period indicated above. It is at present impossible to state to what extent this apparent gradual

¹ In passing it should be noted that there is a real difference in meaning between *function* in the sense of activity and *function* in the sense of biological use. Almost always in development the first sort of function is propædæutic to the second. This distinction is not sufficiently emphasized in Sir Charles Sherrington's paper, 'On Some Aspects of Animal Mechanism' (*Science*, 56, 1922, pp. 345-355). In this article he considers nerve regeneration, which is a process similar in many respects to nerve development, and asserts that: 'What is constructed is functionally useless until the whole is complete.' In a similar manner, this distinction might modify the argument of Professor Ogden, based in part upon this paper of Sherrington, that intelligent behavior is analogous to nerve regeneration because it too is based upon a 'functionless procedure.' ('Crossing 'The Rubicon Between Mechanism and Life,'" *J. Phil.*, 22, 1925, pp. 281-293).

² Child, C. M., 'The Origin and Development of the Nervous System,' 1921, pp. 114 f.

perfection of behavior was due to a process analogous to very rapid learning, and how much of it was due to the gradual removal of the 'masking' influence of the drug. The observations, however, show no sudden arrival of fitness.

For the reasons given above there is no obligation on the part of the student to assume that behavior in the experimental cases was the result *merely* of the maturation of certain innate factors.

Is it possible, on the other hand, to account for the results of these experiments without any reference to heredity? Dr. Kuo, for example, would dismiss the entire concept of heredity from a behavioristic psychology.¹ May this program be applied to the experimental findings recorded above? It seems to the writer that the facts observed cannot be explained without any reference to heredity. The rapidity and uniformity of the development of the swimming reaction in the experimental larvæ and the unmistakable differences in behavior between the frog and the salamander embryos, even when raised under apparently identical conditions, seems to suggest the basic importance of certain non-environmental influences in the development of responses.

Indeed, it is difficult to see how the facts recorded here, as well as the results of many similar experiments, can be explained save on the assumption that heredity and environment are *interdependently* involved in the perfection of behavior. Is development anything other than a process by which, what is in the last analysis, an hereditary 'given' is transformed by an environmental 'present'?²

If this view be true it will appear that any attempted separation of the parts played by heredity and environment in the drama of development can be in logical terms only. Moreover, the sterile products of such verbal analysis are of more than dubious value to science; they may even do much positive harm in education or industry if applications are based upon them.

¹ Kuo, Z. Y., 'A Psychology without Heredity,' *PSYCHOL. REV.*, 31, 1924, pp. 427-448.

² As I have suggested before (Carmichael, L., *loc. cit.*, p. 260.) this *interdependence* view of the development of behavior has much in common with the 'convergence theory' of Professor W. Stern. Cf. his 'Psychology of Early Childhood,' 1924, p. 51.

In summary, it may be said that the preliminary experiments recorded here successfully demonstrate that in a typical vertebrate form the development of the structures upon which behavior depends may apparently occur during a period when there is no observable response to environmental stimulation. The structures so developed however are not able at their initial appearance to serve the purpose which they ultimately perform in the adult organism. Theoretically, it is held that these facts do not demonstrate that behavior is alone dependent upon the maturation of certain hypothetical innate factors. Likewise the results do not show that all behavior may be explained alone in terms of environmental conditioning. It seems probable indeed that the development of behavior in this typical case, if not in all cases, can only be conceived as resulting from the *interdependent* action of both heredity and environment in determining the functional development of the individual.

DISCUSSION

DR. WATSON'S THEORY OF DEVELOPMENTAL CAPACITY

CRITICISMS AND INTERPRETATIONS

A reading of the three lectures by Dr. John B. Watson which were published in the *Pedagogical Seminary and Journal of Genetic Psychology*, volume 32, number 2, June, 1925, pages 292-371,¹ leads the present writer to believe that there are certain fundamental errors underlying the general theories presented in the first of these lectures.

Whether these errors are tactical, factual, logical, psychological, or biological, that is, to which of these classes the errors belong, the present writer is not prepared to say. Perhaps they are not errors, after all. Still there is much to be said conversely to the general thesis offered in the first lecture. It is the purpose of this paper to treat two aspects of Dr. Watson's general thesis and its corollaries in their relation to the problem of developmental capacity.²

First. Why does Dr. Watson find it necessary to link his findings with theories of structural relationship? Particularly, why is

¹ 'What the Nursery Has to Say About Instincts,' p. 293-327. 'Experimental Studies on the Growth of the Emotions,' pp. 328-349. 'How We Lose and Change Our Emotional Equipment,' pp. 349-371.

² Stated briefly Dr. Watson's thesis and its corollaries are:

"Man is an animal born with certain definite types of structure. Having that kind of structure, he is forced to respond to stimuli at birth in certain ways. . . . Let us call this group of reactions, man's *unlearned behavior*.

" . . . Everything we have been in the habit of calling an 'instinct' today is a result largely of training—belonging to man's *learned behavior*.

"As a corollary from this, I wish to draw the conclusion that there is no such thing as an inheritance of *capacity, talent, temperament, mental constitution, and characteristics*. These things again depend on training that goes on mainly in the cradle. The behaviorist would *not* say: 'He inherits his father's capacity or talent for being a fine swordsman.' He would say: 'This child certainly has his father's slender build of body, the same type of eyes. His build is wonderfully like his father's. He too has the build of a swordsman.' . . . A certain type of structure, plus early training—*slanting*—accounts for adult performance." (For a full statement of these three paragraphs see *ibid.*, pp. 292-293.)

it necessary to link them with the external semblances of structure? Is this not harking back to the 'Doctrine of Signatures' of the Middle Ages?

Does Dr. Watson seriously believe that one could say of any child, especially at an early age, that 'he has his father's slender build of body, the same type of eyes. His build is wonderfully like his father's. He too has the build of a swordsman'?

Is it possible to believe that, after all the pains and effort spent yearly on musical failures, every child has nearly equal basic possibilities in this field of accomplishment, provided, of course, he has the proper hand and finger structure (as Dr. Watson seems to contend)?¹ Is it possible that a child who cannot discriminate between two tones varying 18 d.v. can be taught to discriminate as finely as 3 d.v. or even 12 d.v. variations?

The present writer in conjunction with Dr. F. B. Knight has reported the results of a study of the relation between external anatomical structure and traits of character and ability socially judged.² The findings reported indicate relations which can easily be accounted for by chance occurrence. Other investigators studying the relation between anatomical structure, and ability, character, and temperament have reported negative conclusions in every instance. Supplementing these findings the present writer feels that sufficient data are available to warrant a conclusion that certain forms of behavior such as habitual body attitudes, motor adjustments, physiological reactions, expressional changes in voice and speech, adjustments of the mobile portions of the face and other responses of such type do have relation to the character and characteristics of the individual. What these responses reveal are often mistaken as having been revealed to the observer by more or less anatomically fixed forms of external structure. It is in this latter respect that I fear Dr. Watson falls into error in assuming that he discovers clear cut relations between external structure and behavior.

If an appeal to structure is necessary in fortifying behaviorism, would it not be safer to confine that appeal to inner structure, especially, muscular, glandular and nervous structure? Even then is it not possible that such a significant characteristic as plasticity of nervous organization is heritable? Is it not also possible that limitations in nervous mechanism which prevent the establishment

¹ *Ibid.*, p. 301.

² 'Validity of Character Judgments Based on External Criteria,' *J. Appl. Psychol.*, June 1924, 8, No. 2.

of nervous connections necessary for certain acts contributing to practical performances of the individual in certain vocational and artistic executions are transmissible as between parent and offspring? Does not the term aptitude mean the existence of facilities within the organism for making these needed connections? Need it be inconsistent with the fundamental creeds of behaviorism to contend that such facilities can be inherited?

In résumé: The writer believes that there is a fundamental error in Dr. Watson's attempt to link behavior with external indications of structure. The relation between external indications of structure and ability, where it does exist, is largely incidental, slightly significant at times, perhaps, but usually of no practical significance. It is safer, it would seem, both from a theoretical and practical point of view to link behavior with internal structure. From a purely practical point of view, even this step is often not necessary. Granting that a relation does exist between internal structure and behavior does not necessitate a denial of heritable differences in nervous structure which restrict or facilitate individual development.

Second. Does not Dr. Watson erroneously apply the facts available from the study of the conditioning of the emotions to the problem of development of talent? It appears from available evidence that the conditioning of emotions depends, for the greater part, upon the functioning of the *autonomic* nervous system.

Dr Watson has shown that, in the field of emotions, conditioning is rapid, requiring but brief exercise for the connections to be formed, and that such conditioning is involuntary and subject to very wide transfer. Contrary to these findings there is ample evidence from studies of development in the traditional mental functions required by school subjects, skills of trade, and abilities of execution in the arts, to indicate that such development is slower, requires greater frequency of exercise for fixation, is subject to slight transfer and is at inception, usually voluntary. The seat of development of these latter functions seems to be in the *central* nervous system.

By way of building up an interpretation, let me suggest that one developmental capacity, 'intelligence,' is held by many to have been demonstrated to be transmissible from parent to offspring in terms of Mendelian ratios. That mental growth follows a fairly constant increment from birth to a given age varying with individual acumen is, at present, rather widely believed to have been demon-

strated. Evidence also points to the fact that 'intelligence' is a function of the central nervous system. To posit further let me submit that emotional conditioning results in what is commonly thought of as character and temperament. It is usually conceded that emotions are subject largely to the control of the autonomic nervous system.

To me, these facts plus whatever assumptions it is necessary to make because of scanty evidence, point to a theory of developmental capacity contrary to that offered by Dr. Watson. I should say that the psychological make-up of an individual in terms of intellect and certain aptitudes, if you wish, depends upon the connections which may become established in the *central* nervous system. Limitations hindering and facilities fostering the establishment of needed neural connections depend upon inner structure, no doubt, but I should not expect to find very satisfactory criteria of these limitations and facilities in external semblances of structure, say for instance, height, finger-span, or head-girth. There is little question but that the facilities and limitations characteristic of certain developmental capacities are heritable, and even measurable, provided we are successful in determining the proper reaction units.¹

In contrast to the development of mental functions related to certain aptitudes,² the conditioning of emotions is related to the functioning of the *autonomic* nervous system to a marked degree. The conditionings of emotions are quite likely basic in the character development of the individual. Modifications related to the development of character traits are much less subject to limitations than are modifications of responses related to the attainment of proficiency in vocational, artistic and intellectual pursuits. I would not contend that central and autonomic functions are not related, but I would insist that the findings in one sphere or cross-section of human nature do not necessarily hold in the other. Furthermore, the development of the two phases of personality which I have mentioned seem to require a different regimen in the school and in the home.

In résumé: A second fundamental error in Dr. Watson's thesis

¹ This latter hope is not improbable in view of the fact that such a capacity as auditory acuity is determinable. Or for a determination of more complex factors in terms of developmental capacity note Seashore's work on the measurement of musical talent.

² I have suggested that *aptitude* may well be taken to mean *developmental capacity* which in neurological terms means the facility for making needed nervous connections for executions in fields naturally limited by the activities involved.

is held to be the application of findings related to the conditioning of emotions, which depend upon the functioning of the *autonomic* nervous system, in main, to mental and executional functions which depend upon the establishment of connections and channels of nervous activity in the *central* nervous system. By way of interpretation, we submit that the attainment of objectives in intellectual pursuits and in the development of skills of execution in vocational and artistic fields require a different regimen than does the development of traits of character.

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SOME REASONS FOR KOFFKA'S AND THORNDIKE'S OPPOSING VIEWS IN REGARD TO ANIMAL INTELLIGENCE

The widespread interest created by Köhler's recent animal experimentation has naturally led to a renewed interest in previous similar work. Koffka in his book 'The Growth of the Mind' interprets Köhler's work and also compares it with other experimentations, principally Thorndike's. The impression given by Koffka that Köhler's experiments lead to conclusions radically opposed to those derived by Thorndike is being quite generally accepted. It is only when the two treatments of the subject, Thorndike's 'Animal Intelligence' and Koffka's 'The Growth of the Mind' are studied simultaneously that an adequate conception of the *reasons* for the discrepancy of the conclusions derived from the two series of experiments can be obtained.

The following summary includes, perhaps, the crucial points accountable for the divergent conclusions.

I. Thorndike and Koffka start out with different premises.

A. Thorndike: 'We can divide all learning into

- (1) learning by trial and accidental success,
- (2) learning by imitation,
- (3) learning by ideas' (p. 174).

B. Koffka: 'The criterion of insight is found in the animal's capacity to select the indirect way unaided' (p. 181). (Koffka uses the term 'insight' synonymously with 'intelligence'.)

Conclusions reached would not be comparable.

II. Koffka is far more ready with subjective interpretations of objective acts.

A. Koffka:

- (1) (Sultan, scratching his head, moving only eyes, etc.) 'which indicates clearly enough to the observer with what kind of behavior the ape was engaged' (p. 203).
- (2) 'Such changes of expression (face lights up) were also noted by Köhler in his chimpanzees' (p. 182).

- (3) 'From this behavior it may be inferred . . etc.' (p. 196).

B. Thorndike:

- (1) These 'mental characteristics (of the monkey) are of a high degree of importance from the comparative point of view, but they cannot be used to prove that the monkeys have free ideas, for a large number of associations may be acquired after the purely animal fashion' (p. 193.) 'I think it (specious appearance) is likely to lead us to read ideational life into his behavior if we are not cautious' (p. 193).
- (2) 'Their (behavior) interpretation is so dependent on the subjective attitude and prepossessions of the observer, that I prefer not to draw any conclusions from them' (p. 206).

III. Koffka implicitly accepts his own terms.

- A. Situation 'fully comprehensible' to the animal (p. 181).
(Whether it was fully *comprehended* is an open question.)

- B. 'The experiments were so planned that . . . the animal required no knowledge of human contrivances' (p. 181).
(To the animal, are knobs, bars, bolts, loops, etc., more typically human contrivances than boxes, 'detour-boards', swinging baskets, jointed sticks, coiled ropes, etc.?)

IV. Koffka apparently fails to recognize Thorndike's experiments with monkeys.

- A. Despite Thorndike's repeated statements 'mammals, barring the primates' (pp. 66, 67, 173) and frequent emphasis on the essential difference of the anthropoid primates from the cats and dogs, Koffka *never* referred to the Thorndike experiments with monkeys, but cited the experiments with cats, dogs, and chicks as representative of Thorndike's experimentation.
- B. Koffka makes erroneous statement of Thorndike's argument.

- (1) Koffka: 'This conclusion is obvious when we review the two chief arguments advanced by Thorndike in favor of the chance-hypothesis. Thorndike's first argument derived from the form of the time-curve, must certainly be given up; for in view of the long periods of time which often intervened in these experiments before the animal found a solution to the problem, it is quite apparent that time-measurements of the chimpanzee's behavior would not decide the question of chance-insight. These periods were always occupied, either by activities which had nothing whatever to do with the solution, or else by rest' (p. 203).
- (2) Thorndike: 'The times taken by a monkey to get in represent the amounts of his efforts *plus the amount of time in which he is not trying to get in*. It may be said therefore that the time records of the monkeys prove nothing, —that a record of four minutes may mean thirty seconds of effort and three minutes thirty seconds of sleep' (p. 191).
- (3) Koffka: "Thorndike's second argument based upon 'stupid' errors seems to have as little weight as the other" (p. 302).
(Thorndike does not mention 'stupid' errors in connection with monkeys, but with cats and dogs.)

C. Koffka fails to note Thorndike's concessions on animal associations.

- (1) 'The groundwork of animal associations is not the association of *ideas*, but the association of idea or sense-impression with *impulse*.' (p. 106).
- (2) 'There may be a few scattered ideas possessed by the higher animals, but the common form of intelligence with them, their habitual method of learning, is not by the acquisition of ideas, but by the selection of impulses' (p. 284).

- (3) 'The essential thing about the thinking of the animals is that they feel things in gross.' (p. 288). 'The monkey who learned to know K from the letter Y did not feel the separate lines of the letter, have definite ideas of the parts. He just felt one way when he saw one total impression and another way when he saw another' (p. 289).

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THE NATURE OF THE COMPLEX AS COMPARED WITH THE SENTIMENT

The terms 'complex' and 'sentiment,' though very important for psychopathology, have not been able to serve as effective sign-boards to real phenomena because their definitions have been uncertain. The late Dr. W. H. R. Rivers has pointed out the importance of distinguishing between the complex and the sentiment, and has made that distinction clear.¹ The term sentiment, he agrees, is to be used in the regular psychological sense: a sentiment is a natural, normal organization of emotional dispositions about some object, such as of tender emotions about a loved individual. This organization, further, is highly complex, and is an essential factor in those delicately discriminating responses which characterize the normal mind. A complex, on the other hand, Rivers takes to be a distinctly pathological affair, the product of 'suppression' (or, as some would prefer to say, of dissociation); in the language of Freud, the complex is not in 'the fore-conscious,' but is stored away in 'the unconscious.' There it lives until through some crude, indiscriminating eruption its pathological character is revealed. But, as Rivers observes further, 'there is . . . no hard and fast line between the healthy and the morbid, and it is possible, if not probable, that the complex will in some cases shade off into the sentiment . . .'²

This last suggestion brings out an important case of the principle of *relativeness*,³ as that principle is so often found in human problems. For it becomes clear as one observes the workings of meanings which lie beyond 'the fringe' of consciousness, and the 'bubbings up' of elements from subconscious systems into consciousness, that no hard and fast line can be drawn between all sentiments and all complexes. Between the extremes of the descriptive scale, the difference is sharp in accordance with Rivers' definition; but there are plenty of 'border-line cases' in the series.

Also we should note that, apparently due to the inevitable narrowness of 'the field of consciousness' (however this label be interpreted), a very richly constituted sentiment has so many 'roots' in

¹ Rivers, W. H. R., 'Instinct and the Unconscious,' 2d ed., Cambridge Press, 1922, 85-89.

² *Op. cit.*, 89.

³ Cf. Prince, Morton, 'The Unconscious,' Macmillan, 1921, 418-422.

experiences conserved beyond the scope of immediate awareness, that such a sentiment by its very cumbersomeness, so to speak, must function in a manner strongly resembling the behavior of a complex.

This is true, for example, of a mother's sentiment of parental affection for a child that has recently died. No one of the 'neurograms' recording experiences with that child is dissociated from her main consciousness; all those memories, let us say, are fully available to her normal consciousness. Yet the *mass* of such associations, strongly welded together and associated with the emotion of grief, but with only a few of the elements of the sentiment in position at any instant for effective inhibition, functions in the crude mass fashion characteristic of a complex. This situation continues, until, through reflecting on the incidents of the child's life, one by one, the mother associates them with other elements, such as her philosophy, and the pleasures she meets in her daily life. Thus she 'resets' the elements of that sentiment, freeing them from their bondage to a common emotion. The result is that those elements (now really constituents of new sentiments) no longer are set to produce together a single emotion in excessive quantity.

Again, a very frequently practised habit may easily function after the pattern of a complex. A good example is the oft-cited instance of the ex-soldier, who in carrying a kettle of soup across the street dropped it mechanically when some wag bawled out 'Attention'! Here it would seem that the 'Attention' pattern is so well traced or impressed within its own limits that *relative* to the connections between it and properly inhibitory patterns, that 'attention' pattern is dissociated.

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